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MASTER’S PROGRAM IN SPORTS PHYSIOTHERAPY AND REHABILITATION

THE EVALUATION OF SHOULDER JOINT AND CORE STABILITY AMONG WATER POLO PLAYERS

MASTER THESIS

ASLI YERAL, PT., MSc.

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ONAY

Bu tez Yeditepe Üniversitesi Lisansüstü Eğitim-Öğretim ve Sınav Yönetmeliğinin ilgili maddeleri uyarınca yukarıdaki jüri tarafından uygun görülmüş ve Enstitü Yönetim Kurulu'nun 04/10/2019... tarih ve 2019/16-06...... sayılı kararı ile onaylanmıştır.

Prof. Dr. Bayram YILMAZ
Sağlık Bilimleri Enstitüsü Müdürü

DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgement has been made in the text.

ASLI YERAL

DEDICATION

I would like to dedicate my thesis to my beloved and loving parents Neslihan and Ercüment YERAL and my sister Zeynep YERAL for their support.

ASLI YERAL

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LIST OF SYMBOLS AND ABBREVIATIONS

%	: symbol of percentage
°	: symbol of rotation in degrees
cm	: unit of length in centimeters
Hg	: unit of pressure in Mercury
kg	: unit of mass in kilograms
kg/m^2	: unit of body mass index
m	: unit of length in meters
N.m	: unit of strength /Newton meters
Abd	: Abduction
AC	: Acromioclavicular
Add	: Adduction
BMI	: body mass index
BMX	: Bicycle Motocross
CR	: Core region
DMG	: Deep Muscle Group
E	: Erkek
EBK	: Eggbeater kick
ER	: External rotation
FINA	: The International Swimming Federation
HHD	: hand-held dynamometer
HUS	: Head-Up Swimming

IR	: Internal rotation
K	: Goalkeeper
n	: Number of participants
NS	: Neural control system
N-WPG	: Non-Water Polo Group
O	: Offence players
OHT	: Overhead throwing technique
PBU	: Pressure Bio-Feedback Uni
PST	: Posterior shoulder tightness
R	: Right side
RC	: Rotator Cuff
ROM	: Range of motion
SCJ	: Sternoclavicular Joint
SCST	: Sahrmann Core Stability Test
SD	: Standard deviation
SDG	: Smartphone digital goniometer
SGC	: Shoulder girdle complex
SMG	: Superficial Muscle Group
SPSS	: Statistical Package Analyze for Social Sciences
STJ	: Scapulothoracic Joint
TEMET	: Trunk Extensor Muscle Endurance Test
TFMET	: Trunk Flexor Muscle Endurance Test
TLMET	: Trunk Lateral Flexor Muscles Endurance Test

WP	: Water polo
WPG	: Water Polo Group
X	: Defense players

ABSTRACT

Yeral, A. (2019). The Evaluation of Shoulder Joint and Core Stability among Water Polo Players. Yeditepe University, Institute of Health Sciences, Department of Sports Physiotherapy and Rehabilitation, Master Thesis. Istanbul.

The aim of the study is to compare shoulder and core (lumbopelvic) parameters of water polo players (WPG) and non-Water Polo Group (N-WPG). The study included 82 male participants (43WPG /39N-WPG) with a mean age of (16.30±3.42 years) and (15.71±3.30 years) respectively. Both groups were statistically comparable in means of demographic features. Subjects' shoulder flexibility and strength parameters (flexibility of pectoral muscles, posterior capsule flexibility, internal and external rotation (IR/ER) joint ranges, rotator muscle strength, scapular position), core (trunk) endurance and stabilization (trunk endurance and lumbopelvic stability) were evaluated and compared. Goniometer was used to measure ranges of shoulder rotations and posterior shoulder capsule flexibility. The flexibility of the pectoralis minor muscle was recorded as metric data and the rotator muscle strength was evaluated by myometer. McGill Trunk Muscle Endurance Test was preferred to assess the endurance of the trunk muscles and the core (lumbopelvic) stability levels were evaluated by Sahrmann Core Stability Test. According to the statistical analysis, the differences between flexibility of pectoralis minor and shoulder posterior capsule measurements (right / left) were significantly lower in the WPG, indicating stiffness ($p < 0.05$). The shoulder joint IR ranges were more limited in WPG while shoulder ER were higher and both results were statistically significant ($p < 0.05$). Similarly, strength values of shoulder IR and ER (right/left) were higher in WPG ($p < 0.05$). Additionally, trunk muscle endurance values (flexor, extensor and lateral) and core (lumbopelvic) stability values were significantly higher in the WPG ($p < 0.05$). Shoulder joint and core (trunk) parameters of WPG showed statistically significant difference from N-WPG and these results may be considered as risk factors for frequent shoulder problems.

Keywords: water polo, shoulder, external rotation, internal rotation, flexibility, core (lumbopelvic) stability, strength

ÖZET

Yeral, A. (2019). Sutopu Oynayan Sporcularda Omuz Ekleminin ve Kor Stabilitenin Değerlendirilmesi. Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Spor Fizyoterapisi ABD., Yüksek Lisans Tezi. İstanbul.

Çalışmanın amacı; sutopu oynayanlar ile oynamayanların omuz ve kor (lumbopelvik) stabilizasyon parametrelerini karşılaştırmaktır. Çalışmaya sutopu oynayan (43E; 16.30±3.42 yıl) ve sutopu oynamayan (39E; 15.71±3.30 yıl) toplam 82 gönüllü dahil edildi. Her iki grup demografik özellikleri itibariyle istatiksel olarak karşılastırılabilir durumdaydı. Çalışmada olguların omuz esneklik ve kuvvet parametreleri (pektoral kasların esnekliği, arka kapsül esnekliği, iç ve dış rotasyon eklem hareket açıklığı, rotator kas kuvveti ve skapula pozisyonu) ve kor dayanıklılığı ve stabilizasyonu (gövde dayanıklılık ve lumbopelvik stabilite) değerlendirildi. Omuzun iç ve dış rotasyon eklem hareket açıklığının ve omuz arka kapsül esnekliğinin belirlenmesinde gonyometre kullanıldı. Pektoralis minör kasının esnekliği metrik veri olarak kaydedildi ve omuz ekleminin rotator kas kuvveti miyometre ile değerlendirildi. Gövde kaslarının dayanıklılığının belirlenmesinde McGill Gövde Dayanıklılık Testi kullanıldı. Sahrmann Core Stabilite Testi ile kor (lumbopelvik) stabilite seviyeleri değerlendirildi. Yapılan istatiksel analizlere göre, sutopçularda pektoralis minor ve omuz arka kapsül ölçüm değerleri (sağ/sol) istatiksel olarak anlamlı derecede daha düşük yani kısa ve gergin olarak bulundu ($p < 0.05$). Sutopu oynayan grupta omuz ekleminin internal rotasyon eklem hareket açıklığı değerleri diğer gruba kıyasla daha limitli iken, dış rotasyon eklem hareket açıklığı değerleri daha fazlaydı ve her iki değer sonuçları istatiksel olarak anlamlı düzeydeydi ($p < 0.05$). Benzer şekilde, omuz iç ve dış rotasyon kuvvet değerleri (sağ/sol) sutopçularda daha yüksekti ($p < 0.05$). Ayrıca, sutopçularda gövde kas endurans (fleksör, ekstansör ve lateral) ve kor stabilite değerleri anlamlı şekilde yüksek bulundu ($p < 0.05$). Bu çalışma, sutopu oynayan grubun omuz eklem ve kor (gövde) parametrelerinin sutopu oynamayan bireylere göre farklı olduğunu ortaya koydu ve çalışmamızdaki farklılıklar omuz yaralanmaları açısından risk faktörleri olarak düşünüldü.

Anahtar Kelimeler: sutopu, omuz, dış rotasyon, esneklik, iç rotasyon, kor (lumbopelvik) stabilizasyon, kuvvet

1. INTRODUCTION AND PURPOSE

Water polo (WP) is a popular Olympic water-based contact sport that was initially born in England and Scotland as an aquatic version of rugby in the mid-19th century (1). One of the first matches was arranged in New York Athletic Club in 1890. For the first time, men's WP teams (as an Olympic) participated in Paris Olympic Games in 1900 (2). Osborn Swimming Club of England, (Manchester) and Brussels Swimming Club of Belgium competed for final in Paris Games and Osborn Swimming Club was the gold medal winner in Paris Olympic Championship (3,4). The International Swimming Federation (FINA) is the global governing body acknowledged by the International Olympic Committee (5).

While it was a well-known sport formerly in Europe, the popularity of WP has been rising in Turkey since 1934. As a result, the number of teams are increasing gradually. Turkish Men's National WP Team was established by coach Tegethof of Hungary in 1934 (6). After this advent, many young athletes has started training for and participating in national tournaments as well as international competitions (5, 7, 8).

WP can be defined as a physically demanding sport which athletes use their upper limbs as well as lower extremities. Also, WP involves intensive burst during swimming, repetitive throwing, aggressive movements to their opponents and directional changes in numerous periods. Ball throwing with high velocity, high-intensity swimming, playing defensively in overhead position, deny to opponent and using eggbeater kick (EBK) efficiently are considered the main features that players should have for the game (5, 9). For reasons above mentioned, it is thought that players would benefit more from simultaneously swimming in head-up position and dealing with their opponents (1, 2, 10).

Apart from the upper extremity movements which are always used in WP, it is clear that the sport also incuded water polo-specific lower extremity movements in the pool. EBK is defined as a complex legs motion that includes a periodical movement of each leg that is necessary to raise the players' body above the water suddenly with an explosive movement (11). It is explained that players be able to hold their body above the water for a long periods using the EBK during defending, throwing, shooting and passing. Therefore, different and essential skills mentioned above may lead to sports-specific adaptations (9, 1).

It has been considered that athletes need some fundamental parameters in order to use these skills with the correct technique and low energy consumption. These parameters may be interpreted as muscular endurance, flexibility, powerful muscles for stabilization of joints, aerobic and anaerobic power, muscle strength, muscle balance and WP specific skills (10). According to systematic review, lack of these essential parameters are considered as a risk factor for pain and injury (5).

Data of injury prevalence published from the Rio de Janeiro 2016 Olympic Summer Games showed that WP was in top 5 sports branches among most injuries observed. The injury incidences were reported respectively as Bicycle Motocross (BMX) cycling (37.5% of the athletes injured), boxing (30.1%), mountain bike cycling (23.8%), taekwondo (23.6%) and WP (19.4%) (12, 13, 9). Previous descriptive studies reported shoulder injury rates in elite WP players were high as 80% (5, 13). On the contrary to the descriptive studies, systematic review of Miller et al. found that the injury rates for elite male WP players were up to 24% and for college-level men up to 51% (5).

According to the data obtained from Sport Tournaments during the 2004 Olympic Games, WP injuries during competitions was found to be higher than training injuries (14). In the literature, it was reported that 13 % of 260 WP players were injured at the London Summer Olympic Games (2012) (15). Also, in Beijing Olympic Games (2008), a high percentage of competition injuries were indicated in boxing, WP, hockey, baseball and handball (16) (Table 1.1).

Table 1.1. Injury Incidence for Water Polo (WP) Players in Olympic Summer Games (15, 16)

City	Year	Registered Athletes (n)	Injury Incidence in WP (n/ %)
London	2012	260	34 /13.1%
Beijing	2008	259	25 / 9.7%

n: : number of participants.

Studies about WP injuries showed that different anatomical regions were injured (17, 5). It was also reported that the most injured areas in WP players were respectively; shoulder, hand, head, elbow and groin (1). In addition, Webster et al. and Colville et al. reported that the shoulder region could be the most affected anatomical region due to overuse and forceful movements during games (18, 19). In another retrospective study of 13-year period in male WP, Annett et al. reported that 24 % of total injuries were shoulder injuries. Annett's article indicated that shoulder injuries were more likely to become chronic (5, 20).

Different mechanisms of shoulder injury have been identified as muscle strength imbalance within shoulder girdle muscles, hypermobility (overtraining) and rapid rotational movements due to the repetitive movements of throwing, catching and defending (18, 1, 21). Also, lack of the required trunk rotation during throwing (altered throwing techniques) in the WP players may lead to increases in abduction (Abd) and IR ROM. An increased ROM may cause more load on the shoulder muscles (5). Additionally, in a study investigating the gender incidence and injury incidence of injuries, a statistically significant gender difference was found in shoulder injuries. The authors also indicated that the rate of shoulder injuries in female WP players were 2.38 times higher than shoulder injuries in male WP players (22).

The core area can be described as central region in the kinetic chain of sports activities (23). Therefore, the lower extremity may have an active role in the WP as well as the upper extremity. Also, using both extremities effectively in the pool may be associated with a proper technique (23, 24).

WP players are seen to produce their throwing force without the contribution of a solid base of support. Due to the lack of base of support, shoulder of athletes who are playing in aquatic environment is considered more vulnerable to injuries than shoulder of athletes who are playing on land (5). It is thought that kinetic chain mechanism may provide a link between both extremities and may facilitate a transfer of forces to minimize load on primary moving part of the body (24, 25, 26). Likewise, it is reported that core muscles contribute to approximately 55% of the kinetic chain mechanism. Due to activation of core muscles, lumbopelvic area may be considered as a supportive region of WP players' need of excessive muscular force during competitions (27, 28).

Regarding these points mentioned above, aims of the study were to compare shoulder parameters and core (lumbopelvic) stability values between Water Polo Group (WPG) and non- Water Polo Group (N-WPG) and also to compare shoulder parameters with respect to dominant and non-dominant sides in WPG.

Two hypotheses of this study were:

H0: There are no differences between the Water Polo Group (WPG) and the non-Water Polo Group (N-WPG) in terms of shoulder parameters and core (lumbopelvic) parameters.

H1: There are differences between the WPG and the N-WPG in terms of shoulder parameters and core (lumbopelvic) parameters.

H2: There are differences between the dominant and non-dominant sides in terms of shoulder parameters in WPG.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. Functional Anatomy of Shoulder Complex

The shoulder joint is a spheroid joint between the caput of the humerus and the glenoid fossa of the scapula. There are four joints acting on shoulder movements: Glenohumeral (GHJ), sternoclavicular (SCJ), acromioclavicular (ACJ) and scapulothoracic (STJ). Shoulder joint has the widest range of motion (ROM) of the body. The bone structures that make up the SGC are the scapula, humerus and clavicle. The scapula is linked to the thorax through the AC and SC joints. The shoulder joint needs non-limited mobility for daily life and sports activities. The structure that performs this total mobility is called the shoulder girdle complex (SGC). The SGC is formed by the bones of the humerus, scapula, clavicle and sternum, joints between these bones, joint capsule, ligaments, tendons and muscles. Additionally, another function of SGC is to perform upper extremity elevation (29, 30).

2.2. Joint of Shoulder Girdle Complex (SGC)

The shoulder complex consists of 4 joints, 3 of which are anatomical and 1 of which are physiological. The STJ is not a true synovial joint, it is a physiological joint. Although the ST joint is not a true synovial joint, it is considered as a functional joint due to the sliding surface of the subscapularis and serratus anterior fascia (31, 32).

1. Glenohumeral joint (GHJ)
2. Sternoclavicular joint (SCJ)
3. Acromioclavicular joint (ACJ)
4. Scapulothoracic joint (STJ)

In addition to these four joints forming the shoulder complex, there is a subacromial joint. The subacromial joint is not a real joint but acts as a real joint through the subacromial bursa between the acromion and the humerus. In the ST connection, the arm is in a stable position on the scapula up to the first 60° of flexion and up to the first 30° of Abd. After these angles, 1° movement is happened in the STJ for every 2° movement of the GHJ. GHJ is a top-socket synovial joint between the glenoid fossa in the scapula and the humeral head. This three-axis joint allows flexion-extension, Abd, adduction (Add), IR / ER and circumduction movements. Elevation can be done in three planes. Elevation in the sagittal plane is defined as flexion, elevation in frontal plane is

Abd and elevation in the scapular plane is scaption. Anatomically, stability of the GHJ is more supported by soft tissue than by bone tissue. In the anatomical position, the joint face of the glenoid fossa is in the scapular plane and faces slightly upwards. The ER of the GHJ joint naturally accompanies the Abd movement. Arthrokinematics of ER, the humerus head rolls into the posterior at the glenoid fossa and slides forward. With the contraction of the infraspinatus muscle, a rolling motion of the humeral head posteriorly occurs. Thus, posterior capsule is tightened due to contraction of infraspinatus. Besides, complete Abd of the shoulder complex requires a simultaneous rotation of approximately 60° of the scapula. Arthrokinematics of Abd involves rolling the humerus head down while simultaneously rolling upward on the convex face of the humerus head. At the same time the Supraspinatus Muscle contracts to direct the humerus head to roll upwards. Additionally, IR arthrokinematics is the opposite of the sliding and rolling directions (33).

The upward rotation of the ST joint is an integral part of the overhead activities. This movement provides for glenoid fossa in a safe position to support and stabilize the humeral head. The upward rotation of the scapula is generated with the sum of the clavicular elevation of the SC joint and the scapular upward rotation of the AC joint (Figure 2.1). These two rotations are necessary for a 60-degree upward rotation of the ST joint. The functional ST joint also contributes to arm elevation, which is accomplished by upward rotation of the scapula. In addition to these joints, the first 6 costa and cervicothoracic junction contribute to the elevation movement (32, 33).

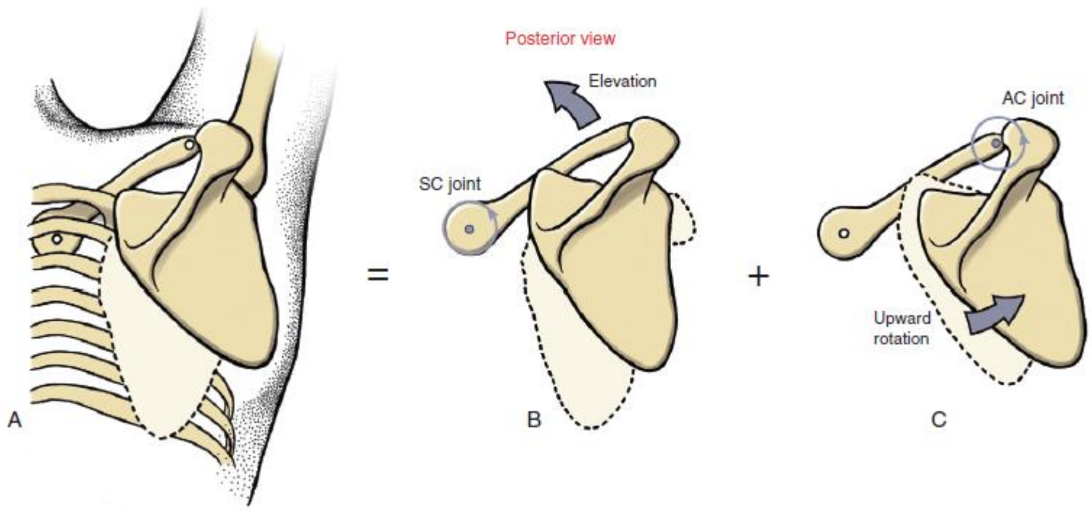


Figure 2.1. A: Scapulothoracic Upward Rotation, B: Elevation in the Sternoclavicular Joint), C: Combination of Acromioclavicular Joint Upward Rotation (32, 33).

2.3. Muscles of Shoulder Girdle Complex (SGC)

The primary muscles that move the GHJ are the anterior and middle parts of the deltoid muscle and the supraspinatus muscle. During flexion movement, the anterior deltoid, coracobrachialis and long head of biceps are contracted. In the Abd movement, the middle part of the supraspinatus and deltoid muscle are contracted. The names of the muscles that fix the scapula to the chest wall are called the Trapezius, Rhomboid Major and Minor muscles (29, 34).

The movements that the scapula can perform except elevation are as follows (34);

- Protraction
- Retraction
- Elevation
- Depression
- Upward rotation
- Downward rotation

Scapular elevation, which occurs with the arm elevation, requires a combination of serratus anterior and lower trapezium muscles and upper trapezium and rhomboid muscles contractions. Other muscles, such as Pectoralis Minor, play a role in scapular stabilization. When the arm is raised upward, the inferior angle of the scapula in rotates superior- laterally (upward rotation). Muscles responsible for arm elevation can be grouped into three groups; muscles that move the GHJ in the first group (deltoid, supraspinatus, coracobrachialis muscles and the long head of the biceps muscle), the second group of muscles that stabilize the STJ (serratus anterior, trapezius muscles), the third group of muscles that stabilize the GHJ (supraspinatus, infraspinatus, sub-scapularis) are found (31). When the arm is lowered, the inferior angle of the scapula rotates in the inferior-medial direction (downward rotation) (33).

The mobility between the upper extremity and the trunk is achieved by the clavicula, scapula, sternum, humerus and the joints between them. Muscles are also involved in the formation of movements. The movements of the GHJ are in three axis and planes. These movements are flexion, extension, Abd, Add, IR and ER (34). The least movement of the arm is extension. Scapular Add is required during extension. Abd movement fixes the humeral head into the glenoid cavity. The first 15° Abd movement is performed by the supraspinatus muscle. The shoulder is known as unstable joint to the movement because it has too large ROM. During movement, the surfaces are generally not compatible with each other. Complete alignment between joint surfaces possible only in Abd and ER movements. There are active structures which are called muscles, that perform movement in the shoulder joint and provide stabilization (29, 30).

The muscles between the axial skeleton and the shoulder complex (34):

<u>Posterior Group Muscles</u>

- M. Trapezius
- M. Levator Scapula
- M. Rhomboid Major and Minor

<u>Anterior Group Muscles</u>

- M. Pectoralis Major and Minor
- M. Serratus Anterior

<u>The Muscles Between Shoulder And Humerus</u>

- M. Deltoid
- M. Subscapular
- M. Supraspinatus
- M. Infraspinatus

- M. Teres Minor
- M. Teres Major
- M. Coracobrachialis

The ligaments of the shoulder joint are long and loose to allow wide movement. Thus, the stabilization of the joint cannot be achieved only by ligaments without the muscles. There are muscles that stabilize the humeral head in every direction. Pectoralis Minor Muscle is involved in the flexion of the arm, IR and Add. Also, the task of the Pectoralis Minor Muscle is to pull the shoulder forward and downward (protraction). Serratus Anterior Muscle is involved substantially in Abd movements of more than 90° of the shoulder. It was accepted as scapular protractor because of its high electromyographic activity during push-ups (35). Some of these structures prevent dislocation of humeral head inferiorly; namely, the short head of Biceps Brachii, the long head of Triceps Brachii and Coracobrachialis muscles. Additionally, Arcus Coracoacromialis support the humerus superiorly. The structure is formed by Coracoacromial ligaments extending between acromion and coracoid process. The shoulder joint is covered form the anteriorly and posteriorly by Deltoid muscles. The Deltoid muscle is a part of the GHJ that allows movement and is also a dynamic inferior stabilizer. Moreover, another task of the deltoid muscles is to perform shoulder extension movement (32, 29).

Rotator Cuff (RC) muscles are one of the most important muscles complex in the shoulder joint. Consists of four muscles and their names are; Supraspinatus, Infraspinatus, Teres Minor and Subscapularis (36) (Figure 2.2). RC muscles contract with muscular activity during arm elevation. The primary function of these muscles is to stabilize the head of the humerus in the glenoid cavities. These supportive structures surround shoulder joint from every direction. Apart from dynamic stabilization, these muscles also play role as passive stabilizers during Abd movement (29, 37 ,38). Shoulder Abd is performed by the Supraspinatus Muscle. In addition, Infraspinatus and Teres Minor provide external rotation (ER) of the shoulder. Infraspinatus also contributes to Abd movement. In addition to the ER movement, Teres Minor also helps perform the Abd movement. The infraspinatus muscle forms an anterior force, stabilizing the shoulder against posterior subluxation during internal rotation (IR). It also supports the shoulder against anterior subluxation while the shoulder is in Abd and ER. Besides, Subscapularis Muscle is a strong adductor and internal rotator (29).

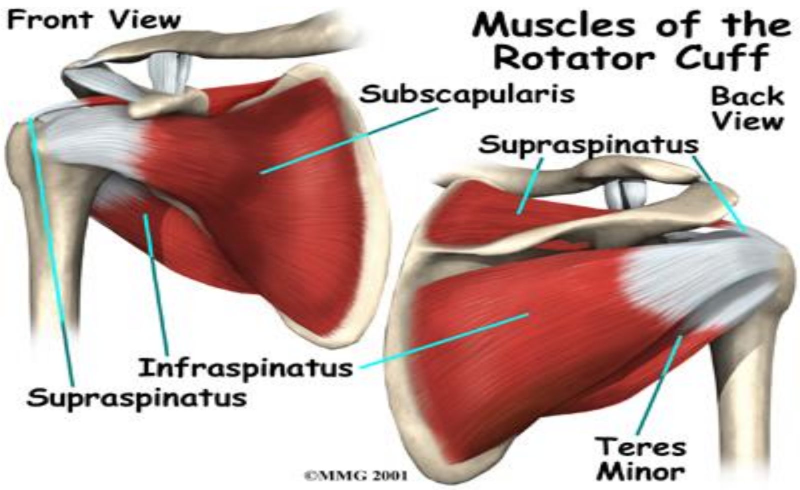


Figure 2.2. Posterior and Anterior View of Rotator Cuff Muscles (36).

Another important stabilizer of the shoulder joint is long head of Biceps Brachii muscles. In a cadaver study conducted in the literature, Biceps Muscle was found to be as effective as a stabilizer as Supraspinatus, Infraspinatus and Teres Minor. The fundamental task of this muscle is to depress the humerus head. It has been reported in the literature that this muscle stabilizes the anterior aspect of the shoulder with its long and short head during arm Abd n and ER (39, 29).

In addition to active structures, passive structures provide stabilization in the shoulder joint. Passive structures are; articular surface, Glenoid Labrum, joint capsule and ligaments. Glenoid Labrum is a dense structure that is rich in fibers. The task of the glenoid labrum is to create a harmonious joint surface and to increase the depth of the glenoid socket (29).

2.4. Shoulder Biomechanics and Kinematics

Elevation in a healthy shoulder can be divided into two phases:

- Early phase (elevation up to 90°)
- Late phase (elevation from 90° to 180°)

In the early phase, 60° of the 90° range of motion consists of elevation in the glenohumeral joint and the remaining 30° of scapular upward rotation. It occurs with 30° scapular upward rotation, 20-25° clavicular elevation in the sternoclavicular joint and 5-

10° upward rotation in the acromioclavicular joint. The upper part of the trapezium muscle and the lower part of the serratus anterior muscle provide upward rotation of the scapula. Deltoid muscle shows activity from the beginning of elevation. Supraspinatus contraction creates a compressive force on the glenohumeral joint at the first 30° of elevation. Subscapularis, infraspinatus and teres minor muscles act as stabilizers in this phase (29). In the late phase, 60° glenohumeral elevation and 30° scapulothoracic upward rotation occur. In this phase, the deltoid muscle reaches the maximum muscular activity at 110° abduction and from this point makes increasingly a plateau, and above 90° the tensile force of the deltoid is minimal. As seen, glenohumeral and scapulothoracic joints are called “scapulohumeral rhythms” and thus work together while maintaining the range of motion. 1° scapulothoracic movement is added to each 2° glenohumeral movement. Although the lifting phase biomechanics of elevation were discussed in the literature, few studies have investigated the lowering phase of shoulder elevation (31).

2.5. Water Polo History in the World and Turkey

Compared to other sports, WP is relatively new. Little information was known about the origin of the WP, but it was known that a Scottish named William Wilson facilitated to create WP in the 1870s. Although swimming clubs in Great Britain and human-made swimming pools were available, but a version of water soccer was started in rivers and lakes. In 1876, rules for WP game was made by Wilson at the request of the clubs. At that time the version was not like modern game of WP, but it involved elements of soccer, diving and swimming (3).

WP was created as an aquatic form of rugby in mid-19th century England and Scotland (40). In the last decades, the popularity of WP has been constantly grown in the USA, Asia, Australia, and Canada (7). For the first time, WP participated in the modern Paris Olympics in 1900. In the Olympics in Paris, players used “pulu,” that pronounced “polo” an inflated, stiffened elastic ball during games. Later, the International Swimming Federation which is called FINA (Fédération Internationale de Natation) applied Scottish-English rules in 1911. Since 1912, the Olympic Games, World Championships and World Cups have been started to held by supervision of FINA (3,4). After the activities of Galatasaray and Istanbul Swimming Specialist Clubs in Istanbul, WP started to be popular nationwide. Teams were also established in other cities (Figure 2.3). The first of these teams was Demirspor of Adana. The team was among the most successful teams in the Turkey. Demirspor team has retained the National Championship for many years in Turkey (6).

Figure 2.3. Young Athletes in an International Competitions

2.6. The Characteristic Features of Water Polo

WP is a highly physically demanding and competitive sport including intense bursts of sprints with repetitive directional changes, interspersed with phases of moderate to high intensity swimming. The game also include aggressive movements such as punching, pulling, kicking and pushing with close touch between players (9, 41, 42) (Figure 2.4).

Figure 2.4. Close Touch Between Players During Game

Also, WP is a team sport that needs a variety of athletic and technical skills depending on every player’s position (43). These technical skills included repetitive overhead throwing, EBK and regular physical contact with least protective equipment. These skills specifically require essential parameters which are endurance, strength, a combination of aerobic fitness /anaerobic power (during swimming), WP-specific skills, muscle strength and nutrition (10). Especially WP players use their upper limbs with forceful bursts of sprint swimming, interchanging direction every 6.2 s, and throwing the ball repetitively from ER, shoulder Abd and at speeds 24.1 ± 1.58 ms−1 (5). The arms are expressly overhead every time for shooting the ball (Figure 2.5). Besides, players must keep their arms overhead position while defending the goal (19).

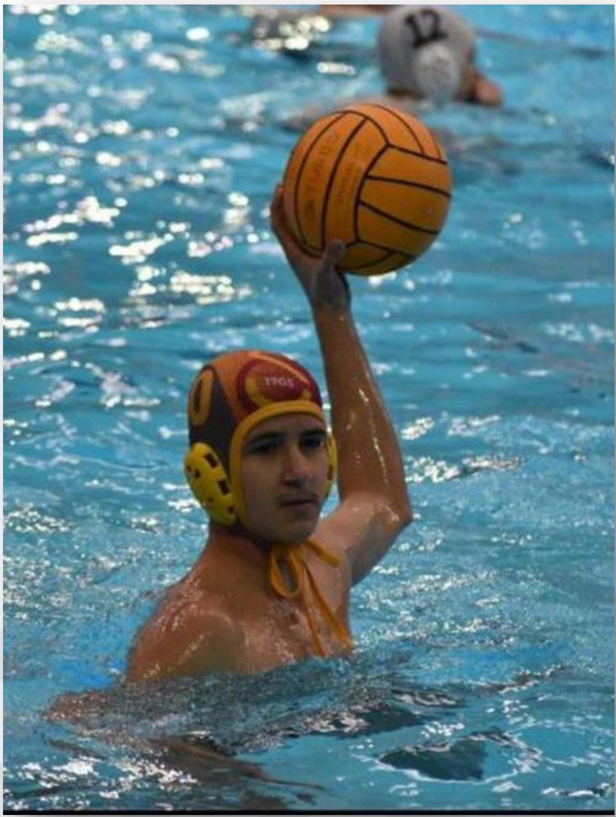


Figure 2.5. Water Polo Throwing

Unlike swimmers, players use different technique which is named a heads-up swimming technique to get a clear view of the ball as well as to permit the athlete to quickly adapt for offensive and defensive sides (44). In contrast to swimming, this technique requires to hold the elbows high, shorten the stroke and decrease the body rotation and enhance the required Abd and shoulder IR (45). It is a sport where not only the upper extremity but also the lower extremity is frequently used. Players must keep their bodies elevated for long periods of time, such as defending, attacking with an attacking player and throwing explosive shots (Figure 2.6). In addition to the upper extremity, trunk muscles and lower extremity are usually used to release explosive force during the game (1).

Figure 2.6. Shooting and Defending with Eggbeater Support

There are two abilities in WP used to lift the upper body. One is conceived to be the "boost", and the other the "hold" as mentioned by Sanders. While using the "boost" ability, the upper body is extracted explosively upwards from the swimming position to attain maximum instantaneous height. With the ability to "hold", the upper body is held in a high position. The swimming position is considered a position in which WP players are immersed in water up to the height of the shoulders, and supported at this SP by small rotational and symmetrical movements of the hands (sculling) and by cyclical motions of lower legs (EBK) (46). Whiting et al. studied throwing motion with two-plane, high-speed, synchronized photography in WP players and concluded that the throwing motion look alike in baseball (47). However, WP players throw the ball without a firm support base during the game (8).

2.7. Physiology of Water Polo

Sport of WP combines swimming with the ball holding. The normal distances that players swim during the WP competition are 1500-1800 meters (48, 49). Eight exercise physiologists have compared some sports in terms of atheltic parameters. In this ranking, WP has the highest athletic parameters compared to other sports. These parameters consist of aerobic endurance, body composition, strength, anaerobic endurance, speed, and agility (48).

Both aerobic and anaerobic systems must be considered in WP players. The reason is that, a large percentile of the swimming was below the aerobic threshold due to the whole playing time (49, 2). According to the different positions of the players, the percentage of aerobic vs anaerobic parameters, roughly is 50-60% aerobic and 30-35% anaerobic (allactic system and glycolytic system) in the game (2). For this reason, increasing aerobic and anaerobic parameters is the best way to improve the muscular and cardiovascular systems required for competition. In addition, the ability of a muscle or group of muscles to maintain high intensity, repetitive static and dynamic exercises are called muscle endurance which is important for WP players (50).

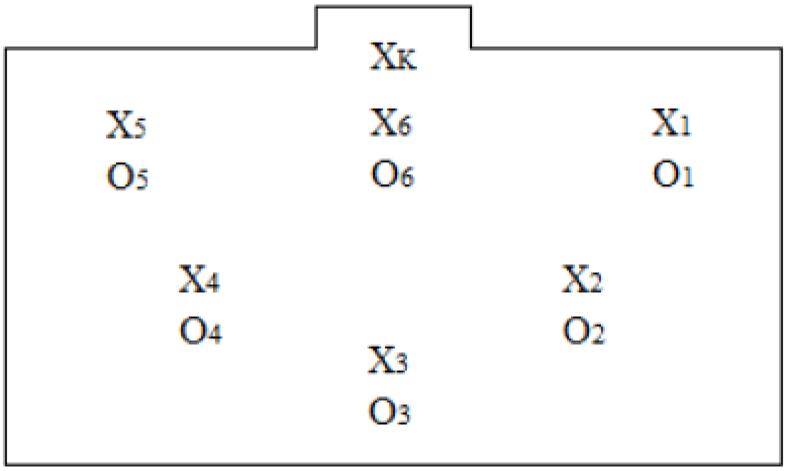
2.8. General Rules in Water Polo During Game

The game is classically played in a pool (30 x 20 m) with a depth of at least 2 m and with seven players including the goalkeeper, for each team (40). According to FINA rules, the WP game duration must include four periods each of 8 minutes present play. Each water polo team has 30 seconds to offense. During the WP game there are 2 breaks in the match. Each break in the match is 1 minute. There are 5 minutes between 2nd and 3rd periods during the match. During breaks, players cannot get out of the pool (48) (Figure 2.7).

Figure 2.7. The position of WP Player in the Water During Break

WP teams consist of 13 players: 11 field players and 2 goalkeepers. There must be 7 players to participate in the game, one of which must be the goalkeeper and the other 6 players must be the field player. Positions of WP players as a defense and offense; goalkeepers, hole set, wings, flats and point (Figure 2.8). During the game, all players have an average of 38.7 passes per player and 7.9 throws per game. The ball weight must be not more than 450 gram and less than 400 gram (43, 51).

Figure 2.8. Player positions and regions; X: defense players, O: offence players, K: goalkeeper, 1-5:



wing players, 2-3-4: field players 6: fixed players (51).

The aim of the game is to throw the ball into the opponent's goal to gain points. This situation must be done using only one hand on the ball but only the goalkeeper might use their two hands during the matches. The opposing team may assault any player keeping the ball, but it is forbidden to hold it under water for detracting from an opponent. If a team holds the ball during the actual game for more than 30 seconds without shooting the opponent's goal, the referee will reset the time (40).

2.9. Biomechanical Principles of Overhead Throwing

Throwing motion is defined as throwing an object into the air with extension and rotation movements involving the entire body. At the same time, neuromuscular coordination is required for throwing motion which is a kinetic chain mechanism (26). This movement occurs when the body segments move respectively and the accumulated force is transferred to the hand (52). Throwing motion starts from large segments with a wide ROM and end in small joints with a narrow range. When the kinetics and kinematics of throwing motion are examined, it starts from the proximal (hip) and ends in the distal (foot) for the lower extremity. According to Newton's third principle, the round reaction force reaches the shoulder through the trunk. While transmitting the force formed in the body, it makes rotation movement to increase the intensity of this force. The movements of the joints for the throwing mechanism (kinetic chain) are as follows (26):

- Outward/inward rotation of spine & back
- Extension to flexion of back and shoulder
- External Rotation to internal rotation of shoulder
- Horizontal Abd- to Add of shoulder
- Extension to flexion of elbow
- Hyperextension to flexion and pronation of wrist and fingers

The forces accumulated in the pelvis are transferred to the shoulder by the upper trunk, resulting in extension of the elbow joint, flexion of the wrist and pronation. Same speed and force do not occur at every phases of the throwing movement. The forces comprise during the lifting of the arm in the sagittal plane are (26):

Initial position: When the muscles are contracted statically, a certain level of potential energy is generated.

When moving from initial position to second: When these contracted muscles release this contraction, relaxation occurs. As a result of the relaxation, all forces which are generate decrease.

When moving from second to third position: As the flexion movement of the arm begins, the forces increases due to the extensors which contract as eccentrically and flexors which contract concentrically. This is maximized level when the arm is in the middle position and the balance between the agonist and antagonist muscles is achieved.

When moving from third to fourth position: As the arm moves against gravity, the shoulder flexors contract concentrically and the eccentric contraction of antagonists begins to decrease gradually. In this position, the shoulder can no longer generate the force, and the arm does not accelerate. At this stage, the potential energy accumulated in the shoulder joint should be transferred to the ball. With the contracting the shoulder internal rotators and pulling in the humerus medially, the increase in arm force occurs.

When moving from fourth to last position: After throwing, the ball starts to travel through air. While the throwing arm increases with the effect of the acceleration it has gained, the force decreases and reaches its initial value.

Last position: The arm is in the air and the muscles are contracted by static contraction. This is the third position where the throwing force reaches the maximum position. In this position with contraction of M. Pectoralis Major and M. Latissimus Dorsi which are powerful muscular components of the shoulder complex, these muscles provide the balance of the shoulder joint.

When starting throwing, deep breathing is provided to increase intrathoracic pressure by Pectoralis Major and Latissimus Dorsi muscles. At the same time this condition is done to increase the potential energy. While throwing with powerful expiration increases the contraction of Pectoralis Major muscle concentrically and the contraction of the Latissimus Dorsi muscle eccentrically. Therefore, throwing force which is generated increase (53). Thus, along the kinetic chain, it is provided to increase the force coming from the foot towards the shoulder by strengthening towards the hand (26, 54)

2.10. The Role of Shoulder Girdle Complex in Throwing

Throwing starts from the lower extremity, but the most important phase is related to the SGC. Therefore, the muscles that form the shoulder girdle and the muscles of the trunk and arm are all involved in the throwing movement. It is necessary to consider the whole extremity when evaluating the motion of the throwing. There is a kinesiological order among the anatomical structures that perform the swing, rotation and release movements that occur in the arm during throwing, this order is controlled by the nervous system (26). Muscles responsible for balance and stabilization of shoulder joint during throwing motions are; Pectoralis Major and Latissimus Dorsi muscles. In addition, M. Pectoralis major and M. Latissimus Dorsi also provide IR during throwing motion. These muscles extend the arm of moment by rotating the humerus inward. In this way, the hand and forearm muscles are formed with a powerful push. Additionally, the sliding movements of the scapula on the thorax play a role in increasing the ROM of the shoulder girdle. With the hierarchical arrangement between the muscles of the neuromuscular structures, the nervous system is also responsible for the necessary coordination and skill as the stabilizer and rotator forces (55).

2.11. Biomechanics of Throwing in Water Polo

WP is a combination of the techniques including in head up swimming and overhead throwing (56). Throwing is considered as one of the most important aspects of performance for WP. There are numerous muscle groups used in the fundamental actions of throwing a ball as well as in “EKB” and “head up swimming”. Torques which are generated by this movements transfer from large muscle groups to small distal muscle groups, thereby increasing the force to be generated in the game. The coordinated movement of these three techniques in the game reveals the balance of muscle activation. Researchers have extensively investigated throwing motions on land but few studies have been conducted on throwing motions in water (57). The WP throwing also differs from the baseball throw in various aspects. The most important aspect is that the athlete does not have a surface to stand on the water. Therefore, there is no fixed support surface from which the athlete can push his body forward, upward and back. Additionally, their legs and arms should continue to execute sculling movements. With the help of the sculling movements, WP players keep their trunk upright position along throwing. Overhead throwing technique (OHT) is performed by releasing the ball from a high point of the head using IR of the shoulder. Prior to the throwing, the ball must be elevated high from the water. The throwing arm is raised and performed shoulder Abd. while rotating the trunk away from the goal. Other arm is in Abd position and shows in the direction of the throw. Throwing starts with the back rotation of the forearm. The front arm is horizontal Abd and reached to begin the trunk rotation (58). Due to differences appear in the throwing such as ball size, lack of ground support, kinematics description of WP throwing is still being investigated in the literature (59).

Besides, trunk rotation provides an essential power source for throwing. Angular momentum is formed by the trunk rotation. Then, this angular momentum is transferred to the throwing arm and shoulder joint. The TR has been predicted to supply 30-35% of the contribution to ball velocity (60). In addition to trunk rotation, the movement and ROM of the shoulder (especially Add and IR) make a big contribution to the ball velocity at the phase of release. If the highest ball speed is to be reached, the elbow extension must be coordinated with the wrist in the final phase of the kinetic chain. Also, it is important to know that water has greater resistance to movement than air (58).

Also, players should be able to raise their bodies more than two meters above water to use their upper extremities effectively during the throwing (61). Throwing technique in WP, with the aid of the trunk rotation and moving from hyperextension to 20° flexion by leaving the ball back of the body generate power to maximize shoulder ER (5). During the game, all players have an average of 38.7 passes per player and 7.9 throws per game (43).

In water polo, the phases of the throwing are as follows (58, 62) (Figure 2.9):

1. Preparation and Backswing (Catching and Cocking)
2. Forward Swing to Release (Acceleration and Relase)
3. Follow Through
4. Contribution of Legs (Eggbeater Kick)

Figure 2.9. Stages of Throwing (62).

2.11.1. Preparation and Backswing

For the backswing phase of throwing, the player first rotates his/her throwing shoulder medially. Then rotates his/her shoulder laterally before the ball and the forward movement of the hand. During backswing phase, the amount of medial rotation depends on the player's ability to control the ball with one hand (58).

2.11.2. Forward Swing to Release

In this phase, the trunk is in hyperextension position during the throwing. Then it moves to a 20° flexion position during the throw. Trunk strength and endurance is an important parameter for forward swing phase in WP. Anterior (flexor) trunk muscles are essential to forward flexion of the trunk during throw. In the releasing phase with the ball behind the body, maximum force must be generated on the ball. This is caused by triceps and anterior shoulder muscles contractions during throwing. The throwing shoulder should perform 90° of Abd. during throw. In addition, the ROM of medial rotation has been determined to range from 40 to 80° and The ROM of horizontal Add. of the shoulder ranges from 50 to 80° during throwing. Because of these reasons, in the literature, it has been predicted that horizontal Add and IR contribute 20-30% to enhancing ball velocity (58, 2). Muscle contractions occur during the throwing: M. Internal and M. External Oblique and also M. Back Extensors are contracted concentrically in the preparation and backswing phases. Pectoralis Major, M. Pectoralis Minor and M. Serratus Anterior are contracted concentrically in the forward swing phase (2).

2.11.3. Follow Through

In this phase, the return of the speed formed on the index finger is applied to the ball by leaving the ball behind the index finger. The speed of the arm should be as slow as possible to avoid damage to the throwing arm. In the ball release phase, the elbow continues to elongate and the wrist flexs. Besides, the ball reaches its maximum speed with pronation of the forearm during this phase. The body segments are gradual decelerated as long as possible to prevent injuries in throwing arm (58, 62).

2.11.4. Contribution of Legs (Eggbeater Kick)

The legs movements during a WP throwing has different goal than in any land sport overhead throwing technique. The extension phase of the legs activates with the forward movement of the throwing arm (2). Core and lower extremities in the WP throwing undertake an assistive role, maintaining balance in the water. Besides, these regions help to get out of the water as high as possible. Legs, also assist to produce the force to be able to get out of the water in WP. In the literature, there is limited number of scientific studies on the contribution of legs to WP throwing (58, 2).

2.12. Biomechanics of Eggbeater Kick (EBK)

The challenge side of WP throwing as compared to other overhead throwing sports is their legs cannot push the ground during force production due to the lack of fixed support. For this reason, the player must constantly beat the legs symmetrically during the match. This movement is named as “EBK” in WP (11) (Figure 2.10). EBK technique is an essential compensatory component since there is no stable point that the body can rotate (58). The EBK is a fundamental technique used in WP. This technique is used in 55% of game duration. It is essential to keep the upper body above water for WP players during some positions. These positions are throwing, passing, blocking and shooting (63). EBK is the presence of symmetrical flexion and extension movements in both knees with cyclical motion of the lower limb (64). Right and left knee movements are similar to each other. EBK includes repetitive rotational movements and high hip flexion, Abd and IR movements are performed at lower extremity periodically (46). These repetitive loads in the groin, knee and hip region are the risk factors for injury. Additionally, large valgus moments are placed across the knee during the downstroke, putting the medial structures (such as the medial collateral ligament) under tension (1). During the EBK movement, M. Hamstring contracts concentrically when the knee flexion. At the same time, M. Quadriceps which is an agonist muscle contracts eccentrically. This cycle continue symmetrically under water for both extremities (58).

Figure 2.10. Eggbeater Kick (2).

2.13. Biomechanics of Head-Up Swimming (HUS)

WP players use a sprint swimming technique with a repetitive movement. During swimming, players' head must be above the water in whole matches (2).

The four phases of HUS are as follows (65):

1. **Early pull-through:** This phase begins when the hand enters the water and when the humerus is perpendicular to the axis of the body, this phase is over.
2. **Late pull-through:** This phase starts at the end of the early pull-through phase. It ends with the hand coming out of the water.

3. **Early recovery:** It starts with the hand exit to the water and when the humerus is perpendicular to the water, this phase is over.
4. **Late recovery:** This phase starts at the end of the early recovery phase. It ends when the hand enters the water.

2.14. Common Injuries in WP

WP is a sport as described above, with rapid movements, repetitive using of body parts and physical contact. Besides, the combination of EBK, repetitive overhead movements are used in WP as throwing, head-up swimming and defending. It has been mentioned in literature that combination of such movements may cause some injuries. These injuries may be acute or chronic (10). During the 2004 Olympic Games, the incidence of injuries for all sports (soccer, WP, handball, basketball, baseball and volleyball) were recorded. According to the results, sports with high rates of competition injury was baseball, WP, boxing, hockey, handball, and judo. In these sports, 50% of injuries were reported to occur while in contact. The Olympic games in 2008 continued to rank almost the same as the 2004 Olympics (66 ,16). 259 WP players participated in Olympic Games (2008), and accounted for 9.7 % of the total competition injury (16). 260 WP players participated in 2012 London Olympic Games and accounted for 13.1% of the total competition injury. The number of participating male WP players was higher than female WP players in London Olympic Games. Rates of overall injuries in female and male WP players in the Olympic were respectively, 8.7 % and 16 % (15). According to data published from the Rio de Janeiro 2016 Olympic Summer Games, WP is among the top 5 sports with a high frequency of injury. The injury incidences are respectively; BMX cycling (38% of the athletes injured), boxing (30%), mountain bike cycling (24%), taekwondo (24%) and WP (19%). According to the results of this Olympic Games, 19% of the 1,101 recorded injuries were WP injuries (13).

Injuries in WP can be seen on all body parts. Ellapen et al. analyzed the prevalence of WP related musculoskeletal pain in competitive adolescent male WP players from South Africa and reported anatomical region where pain is most common as (21);

1. Shoulder (51.4%)
2. Knee (23.95%)
3. Spine (17.71%)

A lot of reviews indicated that shoulder pain in WP players, results from a several factors including repetitive throwing technique, increased shoulder girdle mobility, imbalance of shoulder muscle strength. Shoulder injury is the highest percentage in elite and semi-elite WP players. Webster et al. published an article of shoulder pain in WP and found a high incidence of shoulder pain. However, the underlying cause could not be interpreted (18, 10). There is not only pain in the shoulder but also different shoulder problems such as impingement and tear in the shoulder stabilizer muscles in WP players and all overhead athletes (67, 68). Having repetitive high rate of injury on shoulder in WP players is considered as a risk factor for chronic disability in shoulders problems. Annette et al. followed the incidence of shoulder injury over 13-year period and reported it was 24%. Also, the study was shown that the majority of shoulder injuries were chronic (18, 5).

2.14.1. Mechanism of Shoulder Injuries in Water Polo

The highest percentage of injuries seen in WP are shoulder injuries. Using the wide-angle, repetitive Abd movement during the game cause shoulder injuries in players. Shoulder pain is considered as the most common complaint for WP players. According to scientific literature the incidence of shoulder pain has shown to reach up to 80% (19,7). Impingement syndrome may be encountered in this sport due to excessive use of ER. It is more common injury of Rotator Cuff (RC) Muscles which is consist of tendonitis and rupture in WP players. The etiology of the RC lesions with aging changes to degenerative and chronic. Generally, RC Injuries (tendinopathies, partial and full thickness tears) starts with shoulder pain due to repetitive throwing during the game (19). Additonally to injuries, scapular kinematics changes due to incorrect techniques. Alteration of scapular kinematics is considered as a risk factor for scapular dyskinesia and increased glenohumeral contact surface. The increase in the glenohumeral contact surface result in impingement of rotator cuff (69).

In the literature, pain frequency arises in direct proportion with the frequency of throwing. Numerous ball throws, swim with stroke, or repetitive kicks may result in overuse injuries (7). When players throw the ball with the bluff type and repetitive movements place too much force on the shoulder joint. The force on the joint challenge the physiological limits of the surrounding tissues (5).

The shoulder joint called the swimmer shoulder is hypermobile. This increases the translation of the humeral head in the glenoid space. Also, since it is a contact and defensive sport, athletes face with acute traumatic situations such as contusions, fractures, lacerations, dislocations, sprains at any moment (7, 14). It has been reported in the literature that subluxation and dislocations are encountered in the GHJ due to trauma in WP. In the studies it is stated that the players' shoulder-to-shoulder positions and the situation of moving the ball away from the opponent cause traumatic injuries (5).

2.15. Core (Lumbopelvic Region) Anatomy

The core region (CR), which is the center of force of the body and provides smooth movement of the extremities, is defined as the double-layered cylindrical region between the neck and the hip regions of the body. The CR of the body consists of the spine, abdominal structures, hips and pelvis and proximal lower limbs. These joints are centrally located to perform the balancing functions that the body needs for the distal segments. Also, the CR which is named lumbopelvic complex is supported from all directions by Diaphragm and Abdominal muscles, Oblique muscles, Pelvic Floor muscles and Multifidus muscles. These muscles serve as a corset to support the spine and trunk (70). Also, these muscles provide both stabilization and movement by contracting the muscles with high flexibility and low resistance in the neutral position in the spine. The CR serves as the center for the kinetic chains of sports activities. therefore, it maximizes upper and lower limb function (71).

According to the model explained by Panjabi, the mechanism of core stabilization is controlled by three different systems. These systems are active, passive and neural control. The passive system includes static tissue, vertebrae, intervertebral disc, ligament and joint capsule. The active system includes the core muscles and the muscles responsible for the stability of the spine. The neural control system, is a center for information that goes to and from the brain to maintain core stability at all time. All systems are interrelated, and any one of these systems alone is not sufficient to provide core stability. In order to achieve core stabilization, a repetitive relationship is needed in these three systems (72). The muscles forming the AS are divided into two sub-muscle group (73);

1. Deep Muscle Group (DMG)
2. Superficial Muscle Group (SMG)

The muscles forming the DMG are composed of muscles starting from the spine, adhering to the spine and controlling the segmental movements of the spine. The muscles that make up the SMG allow the movements to be revealed in the body to be transmitted from the ribcage and pelvic region to the limbs (74). DMG is responsible for stabilizing the spine. Deep muscles contract eccentrically to control movement and provide static stabilization. Multifidus and Transversus Abdominis muscles are the primary stabilizer muscles for CR. Transversus Abdominis muscle is activated in healthy individuals before the extremity muscles (75). When these muscles contract, they cannot produce huge movement, which makes them the primary stabilizer. Erector Spinae, Internal Oblique, medial fibers of External Oblique, Quadratus Lumborum and Diaphragm muscles are secondary stabilizer muscles (76, 77).

Multifidus muscle, which plays the most prominent role in spine stabilization from transversospinalis muscles, provides segmental stabilization of the spine and constitutes the primary stabilizer muscle group of the spine (70). The primary ventilation muscle, the diaphragm, contracts and increases intra-abdominal pressure and forms the secondary stabilizer muscle group of the spine. SMG are responsible for the formation of trunk movements (74). Core stability has been considered a dynamic process that is needs optimal muscle capacity (strength, endurance, power) and neuromuscular control (accurate joint and muscle receptors and neural pathways) that can immediately integrate sensory information and change motor responses to internal and external information (27, 78). (Figure 2.11). Crisco and Panjabi have described that these muscles provide dynamic core stability by absorbing loads from the core area in daily activities and sports (79). Core stability requires control of trunk and extremities movement in all three planes. Researches have shown the importance and contribution of core stability to the generation of effective limb movements for the generation, transmission and control of forces during kinetic chain activities. The importance of core stability for sport performance and injury prevention has been popularized in the last decade (80).

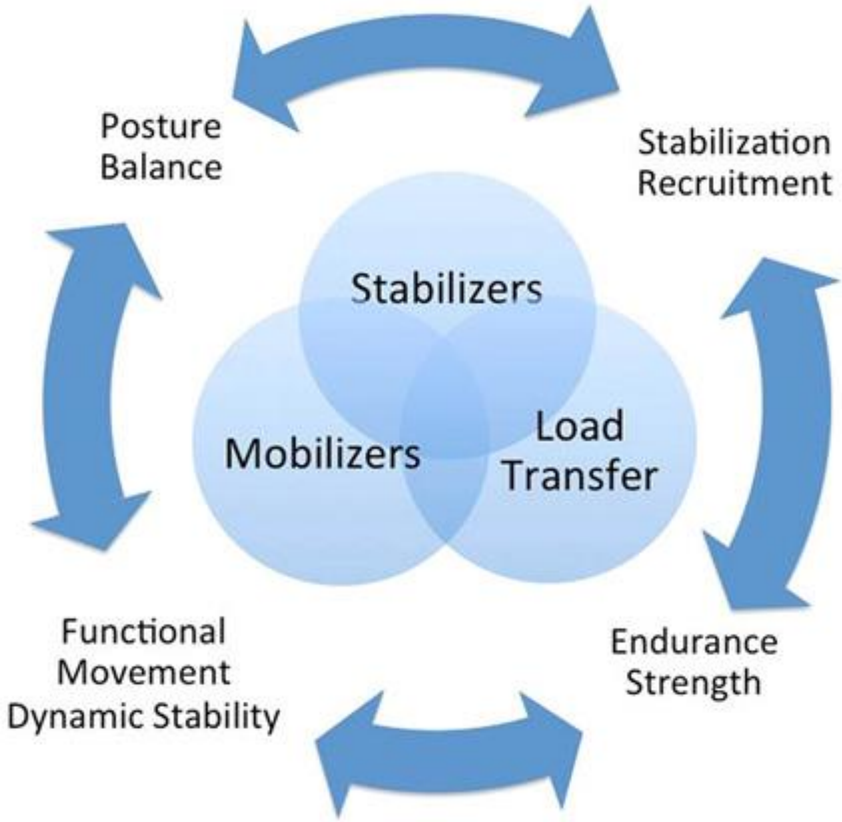


Figure 2.11. Components of Functional Core Stability (78).

2.15.1. Role of Core (Lumbopelvic) Region and Core Stability in Water Polo

The core muscles can contribute to approximately 55% of the kinetic energy to the whole throwing motion. Core stability affects the proximal and distal segments to produce force to maximize athletic function. It also provides control and integration of these segments (71).

Researchers concluded that the CR should include the shoulder and pelvic muscles; as this region is critical for transferring energy from the large body segment to the relatively smaller extremities. This situation is absolutely true for sport-specific movements (81). Studies have shown that the use of all components of the kinetic chain allows the throwers to achieve maximum performance without overloading the shoulder and elbow. Therefore, if the core is weak and the extremities are strong, it is clear that the muscle insufficiency within the core will result in less force generation and inefficient movement patterns. WP players actively use their CR in all positions as the players' feet are not on a fixed surface during the game. Also, players must constantly stand on the water without support surface. In all positions, they try to produce power in a vertical position without the feet on the ground (27).

Kibler et al defines core stability as “the ability to control the position and motion of the trunk. It produces, transfer, and control of power and motion to the terminal segment during integrated complex athletic activities.” This definition indicates that in various sports, powerful forces require active and rapid control and transmission. In order to maximize performance and promote efficient biomechanics, the CR is correctly used to transfer forces to the lower and upper extremities. The importance of core stability has been demonstrated by studies that it is responsible for approximately 85% of the trunk and peri-scapular muscle stability. It has also been reported that it provides the muscle activation required to slow the forward arm during throwing in the literature (82, 83). Besides, muscle capacity, which is the fundamental component of core stability, is represented by the athlete's ability to produce and maintain strength (endurance) within the lumbo-pelvic hip complex. Muscular endurance is explained in different ways. Muscular endurance is the ability of the muscle to maintain submaximal strength levels over long periods of time. In the literature, it is stated that the endurance is related to the ability of the muscle to maintain certain tension over a period of time (84). Throwing, swimming, passing, defending and all water events need controlled postures maintained for long periods of time and dynamic postural control as well as rapid and explosive movements. Elite athletes for rally tournaments need a well-conditioned core, as well as the stability of other primary trunk muscle groups. Thus, it is indicated that stability and endurance are essential and may help to improve dynamic stability of the upper and lower extremities in the literature (85, 86).

3. MATERIAL AND METHOD

3.1. Subjects

The study is comprised of 82 male participants: 43 of them were WP players and the remaining 39 participants served as controls (non-WP players). Water Polo Group (WPG) consists of athletes who regularly play WP as elite and sub-elite (cadet, youth, junior) contrarily non-Water Polo Group (N-WPG) consists of participants who do not regularly exercise in any branches of sport and athletes who do not participate in overhead activities. Additionally, N-WPG consists of high school students studying at Hanife Uysal and university students at Yeditepe University. Ages in the participants of both groups range between 10-30; the median age of the participants was 14 years. Groups included in the study: in the WPG, 37 of them were right-handed and 6 of them were dominant in the left hand; in the N-WPG, 32 of them were dominant in right hand and 7 of them were dominant in left hand.

3.1.1. Inclusion Criteria

- Participating to the study in a voluntary basis.
- Participant in ages between 10-30 years of age.
- Parent permission for participants younger than 18
- Giving consent for older than 18

3.1.2. Exclusion Criteria

- Having a history of orthopaedic surgery in the shoulder girdle within the last 6 months
- Having a history of fracture within the shoulder girdle complex
- Having a shoulder problem within the last 6 months continuing more than 3 months
- Having a history of pathology in lumbar area within the last 6 months

The study protocol was approved by the Yeditepe University Ethical Committee at the date of 11.03.2019 and issue number was 981 (Appendix 1). Participants involved in the study on a voluntary basis. Parents and participants were informed of aim and the methodology of the study. Parent informed consent was obtained from participants younger than 18 years of age while participants over 18 years of age gave consent personally (Appendix 2), (Appendix 3). The study was conducted according to Declaration of Helsinki. Furthermore, participants were informed they were free to withdraw from the study at any time.

3.1.3. Flow of Research

Power analysis was performed to indicate the minimum number of participants required for the study using the PS: Power and Sample Size Calculation version 3.1. According to the result of power analysis, the number of participants to be included in the study with % 80 power with alpha error margin 0.05 and beta 0.20 was determined to be at least 80 individuals. Total of 82 participants (WPG plus N-WPG) participate to the study in compliance with the inclusion criteria: 43 of them were WP players and the remaining 39 were non-WP players. Water Polo Group (WPG) consists of athletes who regularly play WP as elite and sub-elite (cadet, youth, junior) contrarily non-Water Polo Group (N-WPG) consists of participants who do not regularly exercise in any branches of sport and athletes who do not participate in overhead activities. Additionally, the N-WPG consists of high school students studying at Hanife Uysal and university students at Yeditepe University. As for the first step, parents and participants were briefed of the main purpose of the study.

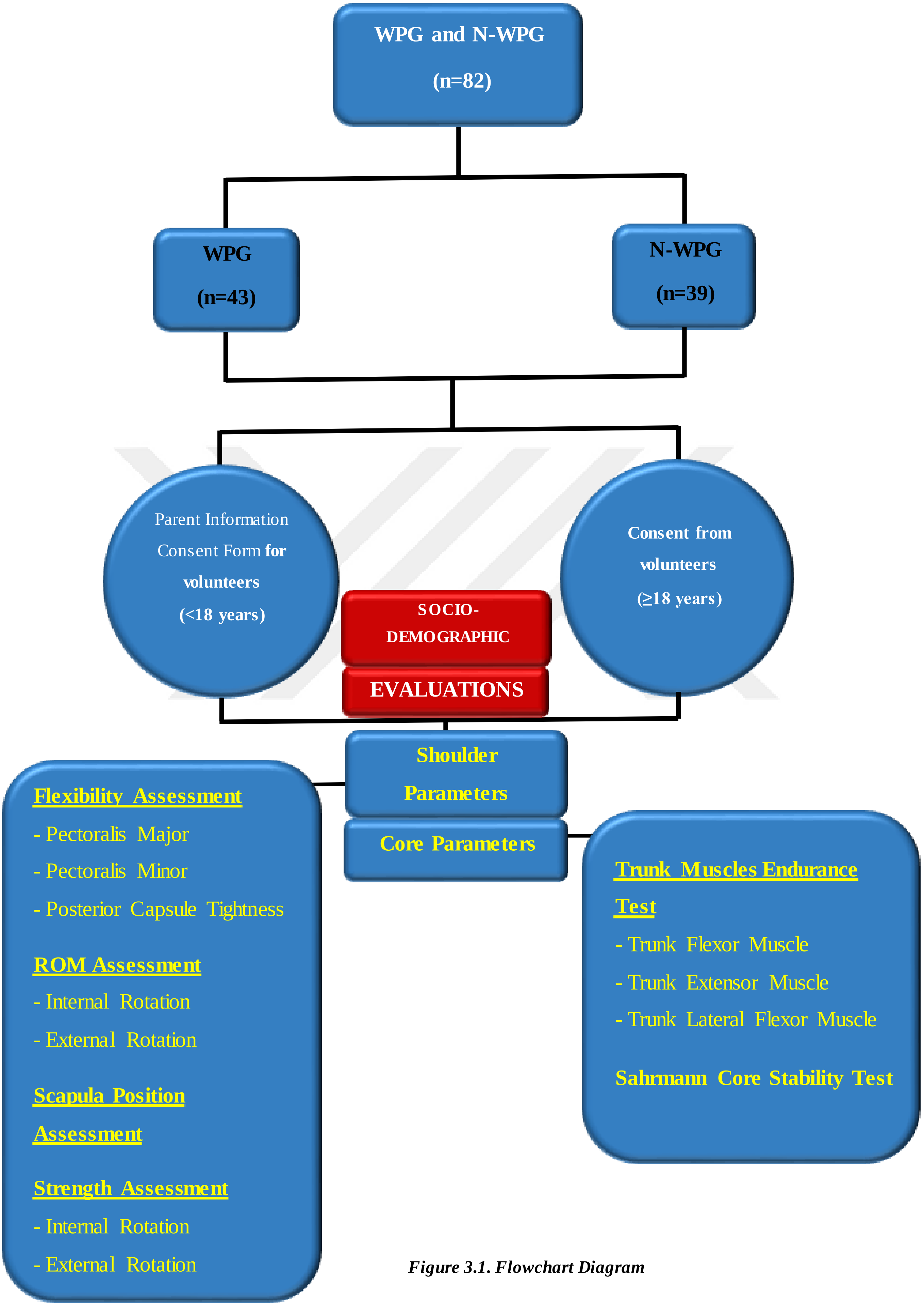


Figure 3.1. Flowchart Diagram

WPG: Water Polo Group, N-WPG: Non-Water Polo Group.

3.1.4. Study Protocol

The study included 82 male participants of which 43 of them were WP players and the remaining 39 participants served as control group (non-WP players). Water Polo Group (WPG) consists of athletes who regularly play WP as elite and sub-elite (cadet, youth, junior) contrarily non-Water Polo Group (N-WPG) consists of participants who do not regularly exercise in any branches of sport and athletes who do not participate in overhead activities. Additionally, the non-Water Polo Group consists of high school students studying at Hanife Uysal and university students at Yeditepe University. Ages in the participants of both groups range between 10-30; the median age of the participants was 14 years. Groups included in the study: in the WPG, 37 of them were right-handed and 6 of them were dominant in the left hand; in the N-WPG, 32 of them were dominant in right hand and 7 of them were dominant in left hand. The requirements for the 43 athletes in WPG to be able to participate in the study: to play WP regularly for more than a year and train at least 3 days/week.

First step of the study was to get Parents' permission via Parent Information Consent Form for participants younger than 18 years of age, while the ones older than 18 gave consent directly by signing the information consent form. Secondly, the structured questionnaire prepared and applied by researchers in face to face interviews to get information about socio-demographic features and injuries of participants. The third step was measurement of specific parameters for both groups by an experienced physiotherapist. Five main parameters of shoulder were assessed: the flexibility of pectoral muscles, tightness of the posterior shoulder capsule, glenohumeral IR and ER, strength of rotator cuff muscles and scapula position. As core parameters, trunk muscles endurance (flexor, extensor and laterals) and core stability were also evaluated (Appendix 4).

3.2. Evaluation

3.2.1. Structured Questionnaire for Participants' Demographic Features

The structured questionnaire prepared and applied by researchers in face to face interviews. The first part of the structured questionnaire included age, gender, height, weight, body mass index (BMI) and dominant hand. The second part was comprised of the exercise behaviors, history of past surgeries, any chronic diseases, pain condition and injury histories (Appendix 5).

3.2.2. Evaluation of Shoulder Parameters

3.2.2.1. Flexibility of Pectoralis Major Muscle Assessment / Sternocostal Portion

Sternocostal portion of Pectoralis Major muscle flexibility was assessed by measurement tape. In the first step of the assessment, participants' shoulders were evaluated while supine on the examination table than the participants' shoulder was passively flexed and moved from flexion to 135° Abd with ER and elbow extension by the experienced physiotherapist. In this position, the distance between lateral epicondyle of the elbow and examination table was measured by the tape. Test was performed for each shoulder. Normal physiological finding is considered as the participants' arm is in full contact with the table (87) (Figure 3.2).

Figure 3.2. Flexibility of Pectoralis Major Muscle Assessment / Sternocostal Portion

3.2.2.2. Flexibility of Pectoralis Major Muscle Assessment / Clavicular Portion

Clavicular portion of Pectoralis Major muscle flexibility was evaluated by tape. First, participants' shoulders were evaluated in the supine position on the examination table. Then, shoulders were flexed and moved from flexion to 90° of Abd with ER and elbow extension. In this position, the distance between lateral epicondyle of the elbow and the table was measured by the tape. Each shoulder was evaluated separately. For this test, normal physiological finding is indicated as the participants' arm is in full contact with the table (87) (Figure 3.3).

Figure 3.3. Flexibility of Pectoralis Major Muscle Assessment/ Clavicular Portion

3.2.2.3. Flexibility of Pectoralis Minor Muscle Assessment

The findings of studies indicate that the pectoralis minor flexibility test is a reliable and valid method to measure the distance from the table to the posterior side of the acromion. In the literature, the Pectoralis Minor length test was used to clinically identify shortening of the muscle that may be associated with clinical syndromes of upper extremities, injury risk and lack of function and pain in the shoulder (87). Current studies have shown that the average measurements of the pectoralis minor length vary between 5.9 cm and 6.3 cm in the asymptomatic group (88). Pectoralis Minor muscle flexibility was evaluated by measurement tape. First step of the evaluation, both shoulders were evaluated in the supine position on the examination table. When both shoulders were in loose position, elbows were flexed on the table with the help of a towel. Use of towel was for reducing the activity of Biceps Brachii and the Coracobrachialis muscles. In the same position, the distance between the acromion of the scapula and the table was measured by the tape. According to test results, normal physiological finding is the shoulder is not be forwardly tilted (87) (Figure 3.4).

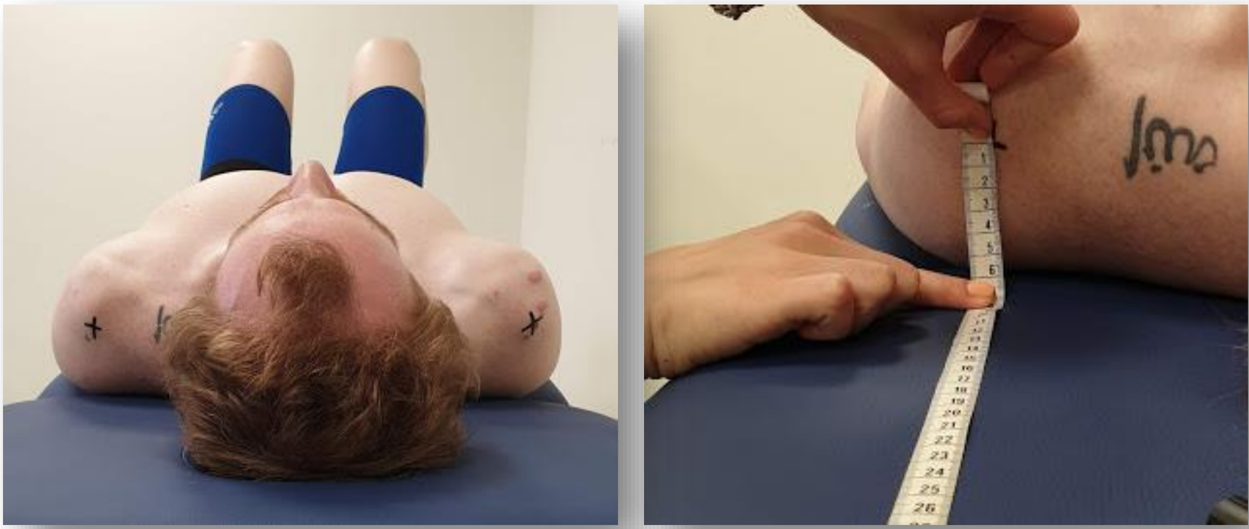


Figure 3.4. Flexibility of Pectoralis Minor Muscle Assessment

3.2.2.4. Assessment of the Posterior Shoulder Capsule Tightness (Flexibility)

Posterior shoulder tightness (PST) of the participants was assessed both manually electronically with using manual and digital goniometer. Measurement of horizontal adduction angle was used to determine PST. A cohort study has showed that the posterior capsule tightness can be evaluated more reliably with the supine method (90). The reason for preferring the supine method is retraction position of the scapula at the initiation. Myers et al used the supine method to identify differences between overhead throwing and control athletes and suggested that the supine assessment more sensitive to determine changes in a population known to exhibit these characteristics (89). In addition, studies were shown that inter-rater reliability of the measurement showed an excellent level of reliability (0.91) in the supine position and a moderate level of reliability (0.83) in the side lying position (89 ,90).

In the first step of the assessment, shoulder was evaluated in the supine position on the examination table. In the position, shoulder was 90° of Abd and elbow was flexed 90° of flexion. Participants were instructed to keep the arm relaxed and while the evaluator stabilized the participants' scapula using the thenar part of her/his hand on the lateral edge of the scapula. Same elevator also used the other hand to move the arm in horizontal Add and the goniometer's axis was placed on ACJ. Then, the goniometer's stationary arm was placed parallel to the ground and the goniometer's mobile arm was placed on lateral epicondyle of the humerus. During the assessment, shoulder protraction and elevation should not be observed. These procedures were performed for the both shoulders one by one. According to test, if the angle of the horizontal Add was small, posterior capsule was considered as stiff (89, 91) (Figure 3.5).

Figure 3.5. Horizontal Adduction Range of Motion (ROM) Assessment

Aside from using the standard goniometer, PST was also evaluated via smartphone digital goniometer (SDG) (G-pro©) which is an iPhone application. This method is considered as an easier and quicker way to evaluate PST than the other measurements (92). Studies show that this new method can be widely used to evaluate shoulder ROM in terms of quickness and comfortableness (93). Studies demonstrated that the G-pro© app has excellent reliability and simultaneous validity with a universal goniometer for measuring ROM (94). Also SDG is a good source for shoulder, knee, wrist ROM measurement in both healthy subjects and symptomatic patients (92).

While the participant was supine on the examination table, with 90° of Abd and 90° elbow flexion. Participants were instructed to keep the arm relaxed. Then, while stabilizing the scapula by the thenar part of the hand on the lateral edge of the scapula, using other hand to move the participants' arm to horizontal Add passively (90). Then, SDG was fixed to the humeral line with elastic band and placed on the upper arm. Additionally, SDG should be in the same direction with the lateral epicondyle of the humerus. When the scapula moved, and the angle on SDG screen was recorded test was terminated. These procedures were performed for both shoulders. As a result, lower angle of the horizontal Add reveals stiffness in the posterior capsule (89) (Figure 3.6).

Figure 3.6. Horizontal Adduction ROM Measurement with Smartphone Digital Goniometer

3.2.2.5. Glenohumeral (Shoulder) Internal Rotation (IR) and External Rotation (ER) Range of Motion (ROM) Assessment

ROM is considered as a valuable diagnostic tool to evaluate the musculoskeletal system. IR and ER ROM measurements are preferred in diagnosis, disability evaluation and outcome analysis. Particularly, it has been concluded in the literature that these measurements can be used to identify athletic injury risk factors for overhead activities and to determine the cause of impaired athletic performance (95). All assessments were in supine position with manual goniometer to determine Glenohumeral IR and ER ROM. When shoulder was at 90° of Abd with 90° elbow flexion and forearm pronated, a towel was placed under the elbow to align their shoulder and elbow (96).

For ER measurement, the goniometer's axis was placed on olecranon process of ulna. Then, the stationary arm was placed perpendicular to the floor and moving arm was placed on ulnar border of forearm toward ulnar styloid process. Participants were instructed to keep the arms relaxed and then the arms were passively externally rotated by the therapist. For IR, the goniometer's axis was placed on the same area. Then, its stationary arm was placed perpendicular to the floor and the moving arm was placed on ulnar border of forearm toward ulnar styloid process. Participants were instructed to keep their arms relaxed and then arms were moved to IR passively. All the measurements were recorded (96) (Figure 3.7).

Figure 3.7. IR and ER Ranges Evaluation

During the measurements, shoulder elevation and shoulder protraction is not permitted and the procedures were performed bilaterally (96).

Aside from using the standard goniometer, this parameter was also evaluated using SDG (G-pro© app) which is the same device used to measure the flexibility of the posterior capsule. At the beginning of the test, shoulders were at 90° of Abd in the supine position with 90° flexed elbows and forearm was pronated (93). Before starting the measurement, the forearm was marked from ulnar styloid to most distal of the ulna and the center device was marked using a board marker. Then, the center of the device was placed with the marked line on ulna using an elastic band and the top of the smartphone was placed on styloid process of ulna. The bottom of the SDG device should be in the same direction as the ulnar line. Subsequently, arms were moved to IR and ER passively and both angles were recorded. These procedures were performed for each shoulders of every participant (93) (Figure 3.8).

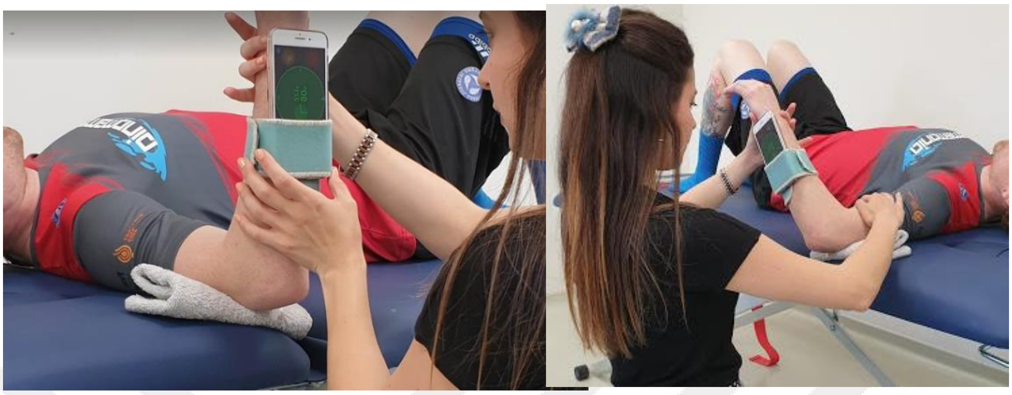


Figure 3.8. IR and ER ROM Evaluation with Smartphone Digital Goniometer (SDG)

3.2.2.6. Evaluation of Scapular Position

In the literature, scapular position of overhead throwing athletes was determined by measuring scapula distance (71). The test which was comprised by Kibler was preferred in WP as it is an overhead throwing Olympic sport (97). The static test assesses the distance between inferior angle of the scapula and the vertebra in standing position. At the beginning of the test physiotherapist signed T7 level of vertebra and inferior angle of the scapula. Distance between T7 level of vertebra and inferior angle of the scapula was measured bilaterally using measurement tape. At the end of the test, the measured distance was recorded as metric data (97).

3.2.2.7. Evaluation of Internal (IR) and External (ER) Strength with Myometer

Measurements of shoulder ER and IR strength were obtained with quantitative myometer using a hand-held dynamometer (HHD) (Commander, JTech Medical, Midvale, UT). A portable, HHD (myometer) has shown to be reliable and easy-to-use method to measure muscle strength in clinical practice. The participants were supine position on the table to evaluate the maximum voluntary isometric strength during muscle contraction of shoulder IR and ER (98).

The shoulders were at 45° of Abd, elbows were flexed at 90° and shoulders were at 30° of horizontal Add with the help of a towel to maintain shoulder Abd. In the position described above, HHD was located on dorsal ulna of the participants' wrist, while the physiotherapist stabilized humerus. Dynamometer was placed on the dorsal side of the wrist before participants were asked to externally rotate shoulders against HDD to evaluate ER strength. For evaluation of IR strength, dynamometer was placed on the ventral (volar) side of the wrist and the volunteers were asked to internally rotated (91). Participants were instructed to perform isometric contraction for 5 seconds during the test. 30 second resting interval between maximal isometric contractions were preferred. The average values of the three trials were noted (98, 99) (Figure 3.9).

Figure 3.9. IR and ER Strength Assessment using Myometer

3.2.3. Evaluation of Core (Lumbopelvic) Parameters

3.2.3.1. Trunk Muscles Endurance Test (TMET)

A number of isometric tests of trunk muscles endurance have been described for the trunk flexors, extensors and lateral muscles (100). McGill's assessment method which is applied by minimal and inexpensive equipment was preferred (101). This test is a safe and easy to apply in clinical setting. The performance is evaluated by recording the maximum time a person can maintain the test position. This test consists of 4 sections and between each section has 5 seconds rests. Besides, the endurance time was manually recorded by stopwatch (102).

3.2.3.1.A. Trunk Flexor Muscle Endurance Test (TFMET)

TFMET was used to evaluate trunk flexor muscle endurance capacity of participants. The test was conducted using stop-watch. In the first stage, the volunteers were in a sitting position on the table. Then, hip and knees were flexed to 90° and the torso was to 60° of angle with a supporting wedge from the table. In this position, arms were crossed across the chest and strap was used to fix feet to table and maximum time participant can maintain the position is recorded (102, 84) As a result, termination criteria of the test is fall of the trunk below the 60° angle, disruption of participants crossed arms position on the chest, protraction of shoulders and developing kyphotic posture (78, 27) (Figure 3.10).

Figure 3.10. Trunk Flexor Muscle Endurance Test

3.2.3.1.B. Trunk Extensor Muscle Endurance Test (TEMET)

TEMET is a modification of the Biering-Sorensen Test. TEMET was preferred for its decent reliability in order to evaluate isometric trunk muscle strength (100). Assessment of trunk extensor muscle endurance was conducted by using a stop-watch. Participants were positioned in prone lying with the spina iliaca anterior superior (SIAS) level on edge of the table. Lower body were stabilized with help of the straps (102). The upper body was supported by hands before initiation of the test. With the initiation of the test, participants were requisitioned to hold their upper body parallel to the ground with the hands crossed over the chest (27). Participants were instructed to maintain the horizontal position as long as possible. Disruption of upper body's horizontal position and participants crossed arms was termination criteria of the test (78).

3.2.3.1.C. Trunk Lateral Flexor Muscles Endurance Test (TLMET)

The lateral trunk muscles endurance evaluation of participants for both sides were measured by a stop-watch. At the beginning of the test, participants were side-lying position on the exercise mat with extended legs and arm must be in full contact with the body (102). As soon as the participants lift the hips, the test was initiated. With the initiation of the test, participants were requisitioned to maintain a straight line along with the vertebrae by controlling lateral flexor muscles of the trunk. Participants were instructed to sustain this position as long as possible. According to test procedure, only the feet and elbow of participants were allowed to support the body. Termination criteria was drop of the hip (84) (Figure 3.11).

Figure 3.11. Trunk Lateral Flexor Muscles Endurance Test

3.2.3.2. Sahrmann Core Stability Test (SCST)

Core stability was detected by SCST. Evaluating core stability is complex due to described tests and the lack of a standard measurements. Stanton et al. used the SCST to assess core stability of male athletes (103). This test consists of 5 levels and increasingly difficult with each level.

Assessment was conducted in supine position by Stabilizer Pressure Bio-Feedback Unit (PBU) (Chattanooga Group, Inc., Vista, CA) (Figure 3.12). In the position, the PBU was placed on under lumbar spine (level of L2 and L3 vertebrae). At the beginning of this test, the physiotherapist demonstrates the maneuver of abdominal wall hallowing to the participant (81). Then, the pressure level of the bio-feedback unit was inflated to 40 mm-Hg and instructed participants should maintain pressure in 40 mm-Hg during the test (104, 103) The scoring of the test was performed in proportional increments of the test levels.

Figure 3.12. Stabilizer Pressure Bio-Feedback Unit (PBU)

Level 1: At the beginning of the first level, participants were requisitioned to perform 100° of hip and 90° of knee flexion on the table with crook lying position of one leg. In this position, participants were instructed to hold pressure in ranges between 40 mm Hg ±10. If 1^{st} level was satisfactory, participant can pass on to higher level 2 (104, 105) (Figure 3.13).

Figure 3.13. Sahrmann Core Stability Test, Level 1

Level 2: In the position mentioned earlier, participants were positioned to 100° of hip flexion and 90° of knee flexion for both legs and is asked to extend the leg with heel contact to the ground one by one. During the test, there should be no change in pressure gauge for each level. Thus, participants maintain pressure which was desired until the test completes. In final phase of second level, if 2nd level is accepted, participants can pass on to level 3 (104, 105) (Figure 3.14).

Figure 3.14. Sahrmann Core Stability Test, Level 2

Level 3: Participants were positioned 100° of hip flexion and 90° of knee flexion for both legs in the same position. Then, participants extend their leg along the table one by one without heel contact and keep pressure constant which was desired for this position. At the end, if 3rd level is performed correctly, participants can pass on to level 4 (104, 105) (Figure 3.15).

Figure 3.15. Sahrmann Core Stability Test, Level 3

Level 4: In the position mentioned above, participants were positioned 100° of hip flexion and 90° of knee flexion for both legs. Then, therapist instructed participants to extend both of legs along the table with heel contact and participants maintain same pressure level until the test is completed. In conclusion, if 4th level is performed correctly, participants go on to level 5 (104,105) (Figure 3.16).

Figure 3.16. Sahrmann Core Stability Test, Level 4

Level 5: In the last level, participants were positioned to 100° of hip flexion and 90° knee flexion for both legs. Then, participants extend both legs along the table without heel contact. Participants maintain same pressure level until the test is completed in the position (104, 105) (Figure 3.17).

Figure 3.17. Sahrmann Core Stability Test, Level 5

Data Analysis

Statistical Package Analyze for Social Sciences (SPSS) version 22.0 was used for data analyses and the Kolmogorov-Smirnov test was preferred to test the numerical variables for normality. The summary of numerical data was showed as mean ± standard deviation. Statistical analysis was performed for parametric data using with Independent Sample T-test and Paired Sample T-test. The significance level was accepted as 0.05.

4. RESULTS

The study included 82 participants (n=82, 43WPG /39N-WPG) of which 43 of them were water polo players (WPG) and the remaining 39 serving as controls were not water polo players (N-WPG).

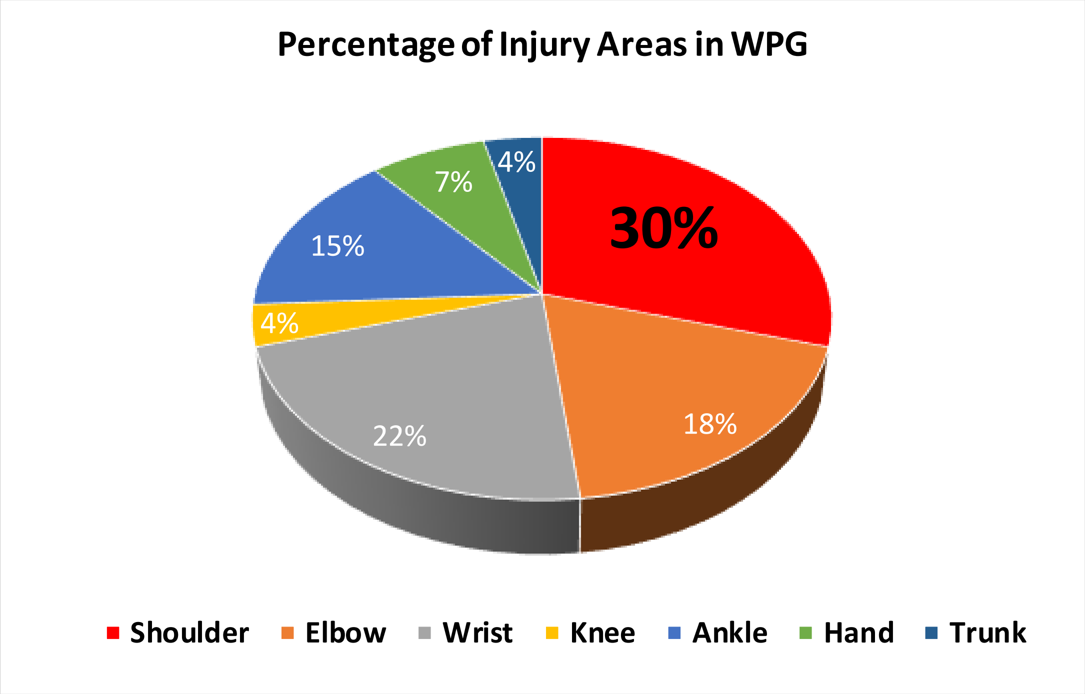
The physical features (age, weight, height and body mass index (BMI) of both groups are shown in Table 4.1. Statistically, while there were no differences in age, weight and BMI, only height had statistically differences in two groups **($p < 0.05$)**. Both groups were statistically comparable in means of demographic features. The mean of height was higher in WPG **(Table 4.1).**

Table 4.1. Physical Features of Participants

	WPG (n=43) mean±SD	**N-WPG (n=39) mean±SD**	**t**	**p value**
Age (year)	16.30±3.42	15.71±3.30	0.78	0.43
Weight (kg)	70.18±12.70	64.46±17.22	1.72	0.89
Height (m)	177.30±9.54	169.05±11.63	3.52	**0.00**
BMI (kg/m^2)	22.00±2.39	22.30±4.35	-0.37	0.70

Data expressed as mean ± standard deviation. BMI: Body Mass Index. SD: Standard deviation. n: number of participants. WPG: Water Polo Group, N-WPG: Non-Water Polo Group

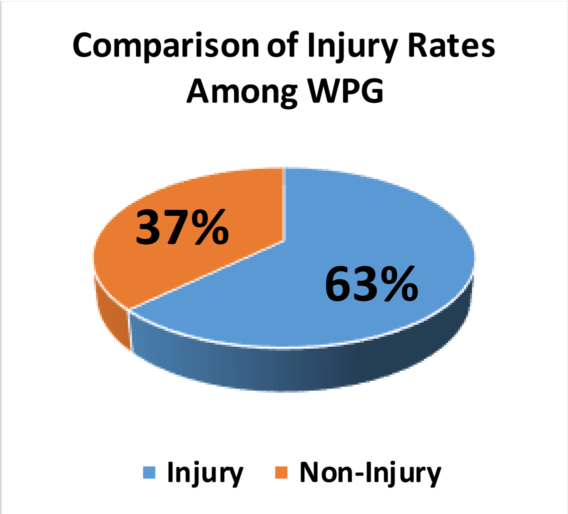
Percentage of injury and pain areas in WPG are shown in Graph 4.10. % 30 of WPG participants had previous shoulder injuries or shoulder pain in the last five years **(Figure 4.1).**



WPG: Water Polo Group

Figure 4.1. Percentage of Previous Injury and Pain Areas in WPG

Comparison of Injury Rates Among WPG and N-WPG are shown in Graph 4.11. 63% of WPG participants and only 21% of N-WPG participants suffered injuries in the last five years **(Figure 4.2).**



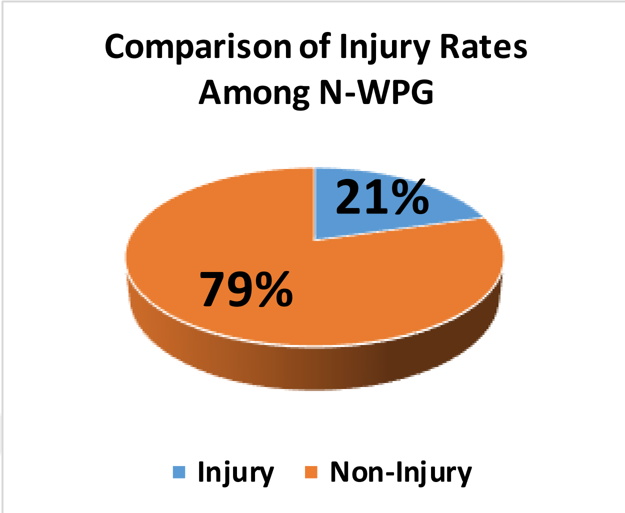


Figure 4.2. Comparison of Injury Rates Among WPG and N-WPG

Frequency of Training Regimen in WPG are shown in Graph 4.12. 61% of WPG participants perform 7 days of training in a week. **(Figure 4.3).**

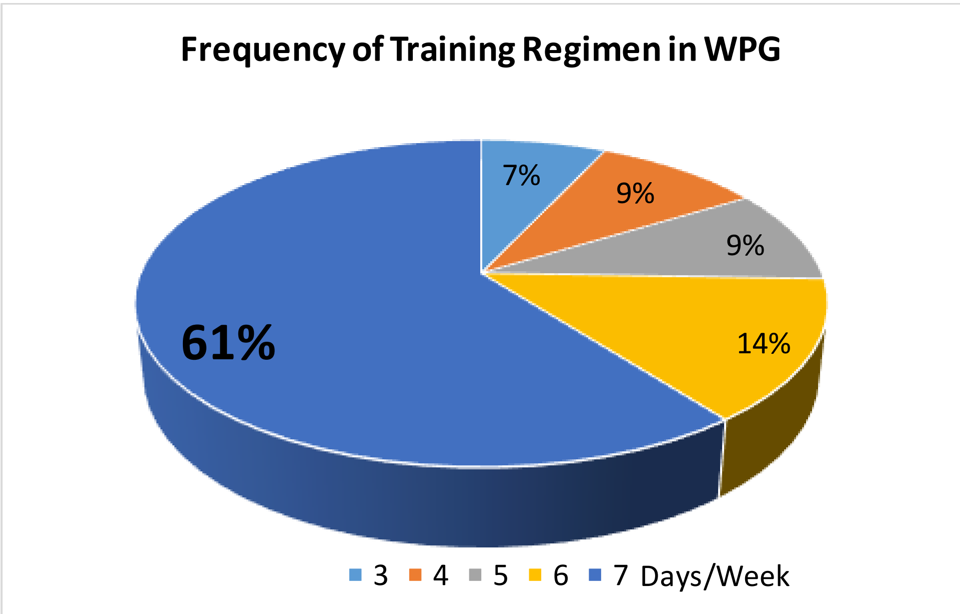


Figure 4.3. Frequency of Training Regimen in WPG

The mean values of shoulder evaluations were compared between WPG and N-WPG using Independent-samples t test. All shoulder parameters except horizontal adduction angle on left side had shown statistically significant differences between both groups **(Table 4.2), ($p < 0.05$).**

Table 4.2. Comparison of Shoulder Parameters Between Water Polo Group (WPG) and Non-Water Polo Group (N-WPG)

			WPG (n=43) mean±SD	N-WPG (n=39) mean±SD	t	p value
Pectoralis Minor Flexibility (cm)		Right	5.84±1.28	4.74±1.19	3.99	**0.00**
		Left	5.52±1.32	4.56±1.08	0.17	**0.00**
Horizontal Adduction (degree)		Right	18.18 ± 2.64	22.12 ±3.06	-6.20	**0.00**
		Left	21.58±2.61	22.66±3.21	-1.66	0.10
ROM (degree)	**IR**	Right	57.95±4.38	66.84±2.78	-10.51	**0.00**
		Left	63.41±3.83	68.79±1.39	-8.26	**0.00**
	ER	Right	94.60±5.76	89.28±2.56	5.14	**0.00**
		Left	92.67±4.89	89.84±0.70	3.57	**0.00**
Scapula Distance (cm)		Right	8.50 ±0.53	7.42±0.13	12.17	**0.00**
		Left	8.47±0.61	7.45±0.13	10.23	**0.00**

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. ROM: Range of Motion, IR: Shoulder Internal Rotation, ER: Shoulder External Rotation, R: Right. WPG: Water Polo Group.

Paired-samples t test was used to investigate differences in regard to mean scores of shoulder parameters between right and left sides According to analyzes, pectoralis minor flexibility, horizontal adduction angle, shoulder ranges (IR/ER) values in WPG showed statistically significant differences in right and left. **($p < 0.05$)**. In contrast, there was a no statistically significant difference in scapula distance measurements of the WPG between both sides **(Table 4.3)**, **($p > 0.05$).**

Table 4.3. Intragroup Comparison of Shoulder Parameters for Right and Left Side in WPG

			WPG (n=43) mean±SD	p/t
Pectoralis Minor Flexibility (cm)		Right	5.84±1.28	**p= 0.00** t= 4.31
		Left	5.52±1.32	
Horizontal Adduction (degree)		Right	18.18±2.64	**p= 0.00** t=-7.21
		Left	21.58±2.61	
ROM (degree)	**Shoulder IR**	Right	57.95±4.38	**p= 0.00** t= -7.11
		Left	63.41±3.83	
	Shoulder ER	Right	94.60±5.76	**p= 0.00** t= 4.04
		Left	92.67±4.89	
Scapula Distance (cm)		Right	8.50±0.53	p= 0.47 t=0.72
		Left	8.47±0.61	

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. IR: Shoulder Internal Rotation, ER: Shoulder External Rotation, ROM: Range of Motion. WPG: Water Polo Group.

Pectoralis Minor flexibility, horizontal adduction angle, shoulder renges (IR/ER) and scapula distance values in N-WPG were given in Table 4.4. Paired-samples t test was used to compare values between both sides in N-WPG. There were statistically significant differences in Pectoralis Minor flexibility, shoulder IR range and scapula distance between dominant vs. non-dominant shoulders **($p < 0.05$).** No statistically differences were found in shoulder ER range and horizontal adduction angle between both sides **(Table 4.4), ($p > 0.05$).**

Table 4.4. Intragroup Comparison of Shoulder Parameters for Right and Left Side in N-WPG

			N-WPG (n=39) mean±SD	p/t
Pectoralis Minor Flexibility (cm)		Right	4.74±1.19	**p=0.00**
		Left	4.56±1.08	t=3.38
Horizontal Adduction (degree)		Right	22.12±3.06	p=0.35
		Left	22.66±3.21	t= -2.18
ROM (degree)	**IR**	Right	66.84±2.78	**p= 0.00**
		Left	68.79±1.39	t=-5.59
	ER	Right	89.28±2.56	p=0.09
		Left	89.84±0.70	t= -1.70
Scapula Distance (cm)		Right	7.42±0.13	**p=0.00**
		Left	7.45±0.13	t=-3.07

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. IR: Shoulder Internal Rotation, ER: Shoulder External Rotation, ROM: Range of Motion. N-WPG: Non-Water Polo Group.

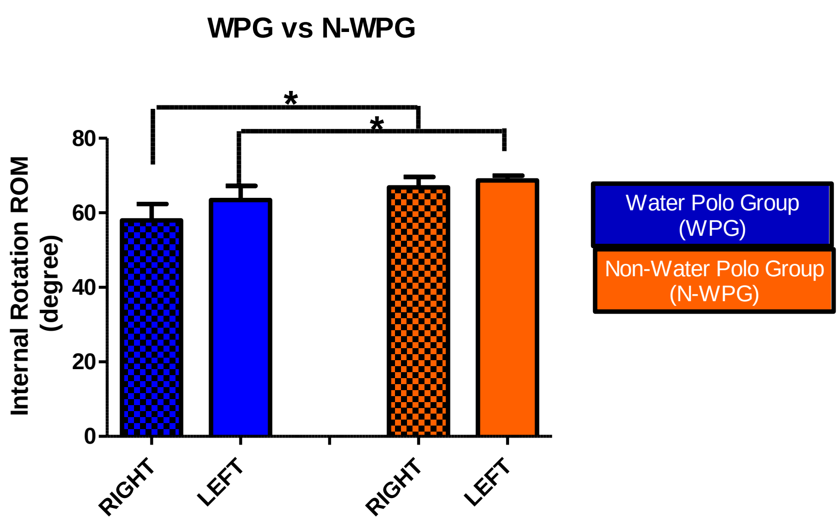
The results of the comparison of the dominant and non-dominant shoulder were shown that pectoralis minor flexibility, horizontal addution angle and shoulder IR/ER ranges values had statistically significant in both sides **($p < 0.05$).** Except for 3 participants, the dominant sides of the participants were right. It means that shoulder parameters of WPG were different between throwing and non-throwing shoulders **(Table 4.5).**

Table 4.5. Comparison of Shoulder Parameters Between Dominant and Non-dominant Sides in WPG

		WPG (n=37) mean±SD	t	p
Pectoralis Minor Flexibility (cm)	Dominant **(R)**	5.85±1.30	7.89	**0.00**
	Non-Dominant	5.41±1.38		
Horizontal Adduction Angle (degree)	Dominant **(R)**	17.97±2.54	-12.47	**0.00**
	Non-Dominant	21.86±2.23		
IR ROM (degree)	Dominant **(R)**	57.37±4.29	-11.20	**0.00**
	Non-Dominant	64.13±3.51		
ER ROM (degree)	Dominant **(R)**	95.08±6.08	5.82	**0.00**
	Non-Dominant	92.54±5.16		

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. IR: Shoulder Internal Rotation, ER: Shoulder External Rotation, ROM: Range of Motion, R: Right. WPG: Water Polo Group.

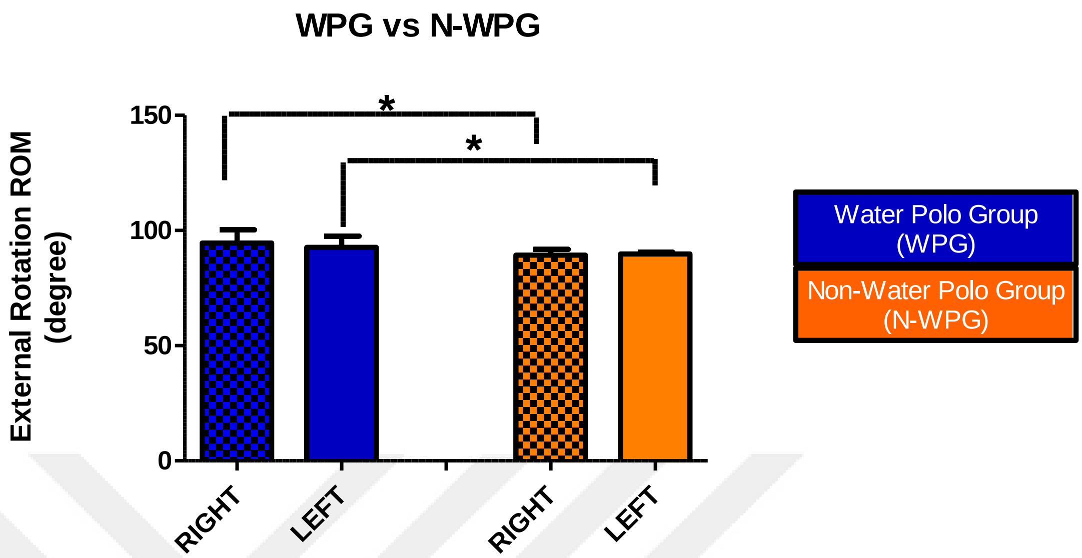
Figure 4.4 showed that the right and left shoulder IR ROM values of WPG were found lower than N-WPG.



***: (p < 0.05).** ROM: Range of Motion.

Figure 4.4. Comparison of Right and Left Shoulder Internal Rotation ROM Between Groups

In the figure comparing the two groups in terms of shoulder ER ROM, right and left shoulder ER ROM values in WPG were found higher than N-WPG **(Figure 4.5).**



***: ($p < 0.05$).** ROM: Range of Motion.

Figure 4.5. Comparison of Right and Left Shoulder External Rotation ROM Between Groups

To compare mean scores of right and left shoulders strength in WPG and N-WPG, we used paired-samples t test. According to intergroup comparison of shoulder strength results, there were statistically significant differences in shoulder IR and ER strengths **($p < 0.05$).** In WPG, the IR and ER strength mean values of the right side **(IR: 135.25±56.06, ER: 108.49±41.92)** were higher than the left side (**IR: 123.47±50.77, ER: 101.06±37.67), (Table 4.6).**

Table 4.6. Intergroup Comparison of Shoulder Strength in Right and Left Side for Both Groups

			WPG (n=43) mean±SD	**p/t**	**N-WPG (n=39) mean±SD**	**p/t**
Strength (N.m)	**Shoulder IR**	Right	135.25±56.06	**p=0.00** t=4.92	74.23±12.71	**p=0.00** t=4.30
		Left	123.47±50.77		68.98±11.28	
	Shoulder ER	Right	108.49±41.92	**p=0.00** t= 4.16	63.69±8.51	**p=0.00** t= 3.69
		Left	101.06±37.67		60.04±9.07	

Data expressed as mean ± standard deviation. SD: Standard deviation, n: number of participants. N: Newton, WPG: Water Polo Group, N-WPG: Non-Water Polo Group, IR: Shoulder Internal Rotation, ER: Shoulder External Rotation.

Table 4.7 showed that there were statistically differences in shoulder strength (IR/ER) values among WPG and N-WPG **($p < 0.05$)**. The mean values of IR and ER strengths in WPG **(IR Rigth:135.25±56.06, IR Left:123.47±50.77; ER Right: 108.49±41.92, ER Left:101.06±37.67)** were higher than other group **(IR Rigth: 74.23±12.71, IR Left: 68.98±11.28; ER Right: 63.69±8.51, ER Left: 60.04±9.07) (Table 4.7).**

Table 4.7. Comparison of Shoulder Strength Between WPG and N-WPG

			WPG (n=43) mean±SD	**N-WPG (n=39) mean±SD**	**t**	**p value**
Strength (N.m)	**Shoulder IR**	Right	135.25±56.06	74.23±12.71	6.64	**0.00**
		Left	123.47±50.77	68.98±11.28	6.55	**0.00**
	Shoulder ER	Right	108.49±41.92	63.69±8.51	6.54	**0.00**
		Left	101.06±37.67	60.04±9.07	6.62	**0.00**

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. N: Newton, WPG: Water Polo Group, N-WPG: Non-Water Polo Group, IR: Shoulder Internal Rotation, ER: Shoulder External Rotation.

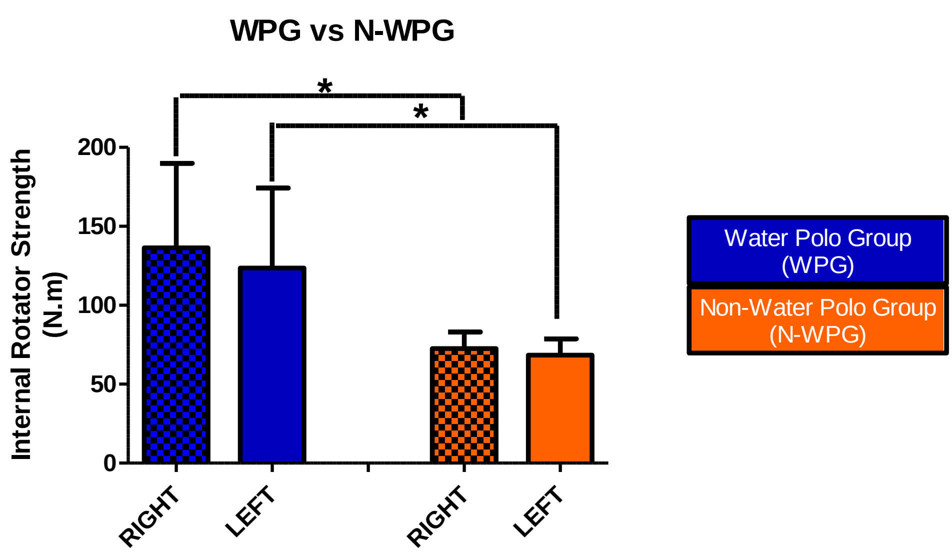
Paired-samples t test was done to investigate shoulder IR-ER strength differences between mean values of dominant vs. non- dominant sides. Except for 3 participants, the dominant sides of the participants were right. According to the analysis of participants with right dominant side, shoulder IR and ER strength values of WPG showed statistically significant difference between dominant and non-dominant sides **($p < 0.05$), (Table 4.8).**

Table 4.8. Comparison of Shoulder Strength Between Dominant and Non-dominant Sides in WPG

			WPG (n=37) mean±SD	t	p
Strength (N.m)	Shoulder IR	Dominant (R)	143.35±53.27	8.68	**0.00**
		Non-Dominant	126.14±51.17		
	Shoulder ER	Dominant (R)	112.00±41.53	4.60	**0.00**
		Non-Dominant	103.22±38.14		

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. N: Newton, IR: Shoulder Internal Rotation, ER: Shoulder External Rotation, R: Right, WPG: Water Polo Group.

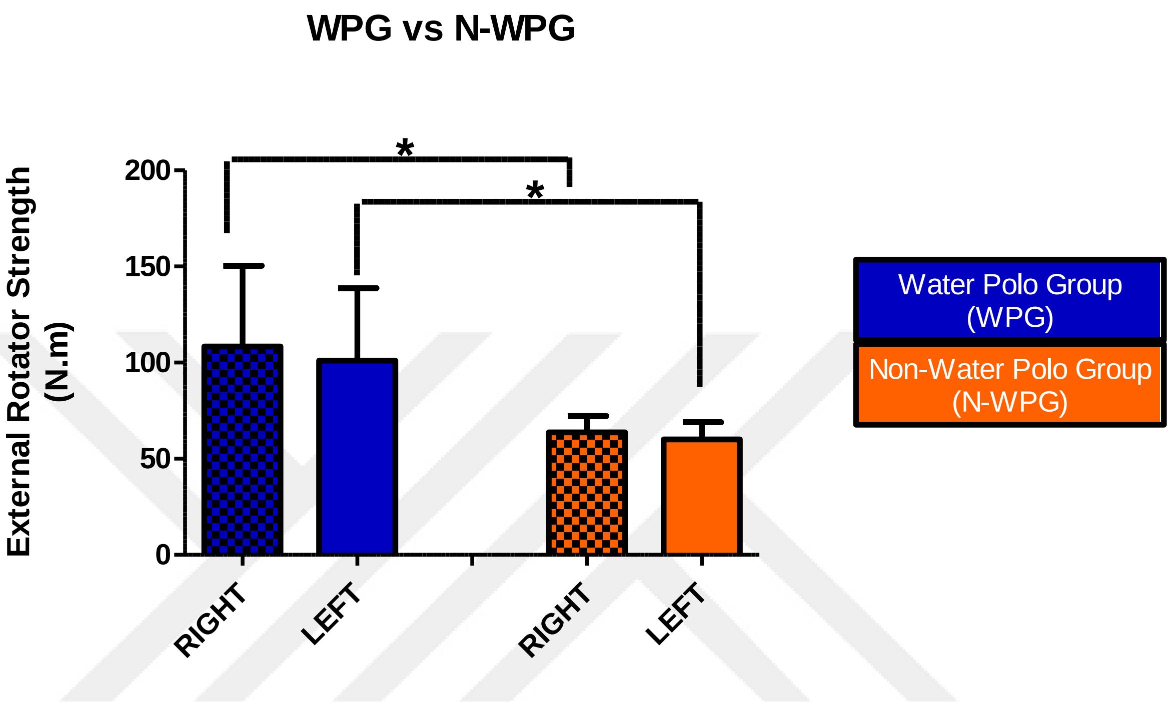
Figure 4.6 showed right and left shoulder IR strength values of WPG were higher than N-WPG.



***: ($p < 0.05$).**

Figure 4.6. Comparison of Right and Left Internal Rotator Strength Values Between WPG and N-WPG

Figure 4.7 were shown, right and left shoulder ER Strength values in WPG were higher than N-WPG.



***: ($p < 0.05$).**

Figure 4.7. Comparison of Right and Left Shoulder External Rotator Strength Values Between Groups

Independent-samples t test was applied to evaluate trunk muscles endurance between WPG and N-WPG. A statistically significant differences were observed in flexor, lateral and extensor muscles' endurance values when compared for both groups **($p < 0.05$).** According to mean values, flexor and extensor muscles endurance **(90.82±17.46, 56.63±13.86)** in WP were found higher than N-WPG **(55.92± 21.80, 32.34 ± 11.00), (Table 4.9).** Besides, the mean value of extensor muscle endurance of WPG was lower than the mean values of flexor and lateral muscles endurance of WPG **(Table 4.9).**

Table 4.9. Comparison of Trunk Muscle Endurance Between WPG and N-WPG

			WPG (n=43) mean±SD	**N-WPG (n=39) mean±SD**	**t**	**p**
Trunk Muscle Endurance (second)	**Flexor**		90.82±17.46	55.92± 21.80	8.03	**0.00**
	Lateral	**Right**	69.15±20.17	41.44±20.71	6.12	**0.00**
		Left	64.50± 24.06	36.62±19.68	5.76	**0.00**
	Extensor		56.63±13.86	32.34 ± 11.00	8.82	**0.00**

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants.

WPG: Water Polo Group, N-WPG: Non-Water Polo Group.

The results of Sahrmann Core Stability Test (SCST) were analyzed by Independent-Samples T Test. There were significant differences in SCST values which were evaluated for both groups **($p < 0.05$).** According to the analysis results, core (lumbopelvic) stability level of WPG were higher than the other group **(Table 4.10).**

Table 4.10. Comparison of Sahrmann Core Stability Test Values Between WPG and N-WPG

	WPG (n=43) mean±SD	**N-WPG (n=39) mean±SD**	**t**	**p**
Sahrmann Core Stability Test (level)	1.48±0.77	0.70±0.31	6.08	**0.00**

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants.

WPG: Water Polo Group, N-WPG: Non-Water Polo Group.

5. DISCUSSION

Altered shoulder mobility has been shown in overhead throwing athletes such as in baseball pitchers, swimmers and WP players. It is believed that there are secondary adaptive changes in shoulder joint due to extreme demands of overhead activities (106) . Additionally, previous descriptive studies revealed GHJ adaptations in overhead athletes (56, 42, 107, 59). In the literature, have been shown these adaptive changes in overhead athletes may lead to shoulder injuries (106, 9, 56, 7). Accordingly, our study design aimed to compare shoulder parameters (flexibility of pectoral muscles, posterior capsule flexibility, IR and ER ROM, rotator muscle strength and scapula distance) and core stability (endurance time and stability level) among WPG and N-WPG. Moreover, this research evaluated shoulder parameters of dominant side and non-dominant sides in WP players.

The main findings of our study were that reduced shoulder IR, posterior shoulder capsule tightness and reduced Pectoralis Minor flexibility in WP players (Table 4.2). According to the results of the core evaluations, even though trunk muscle endurance (flexor, extensor and lateral) are higher in WPG compared to the N-WPG, interestingly extensor muscle endurance was lower than endurance parameters of other trunk muscles in WP players (Table 4.9). Consistent with our hypothesis, shoulder parameters of WP players differed from the dominant side to the non-dominant side (Table 4.5), (Table 4.8).

In our study, IR and ER ROM outcomes of WPG showed statistically significant differences among both groups ($p < 0.05$). The mean values of IR ROM in WPG were found to be limited while the mean values of shoulder ER ROM in WPG were higher. (Table 4.2). Similar to our study, Elliott reported WP players had a lower IR ROM than the control group (44). Thus, it was thought that in addition to the IR limitation in WP players, the glenohumeral internal rotation deficit (GIRD) could be present with the further reduction of the IR ROM angle. Devine indicated that collegiate WP players had less IR ROM and high ER ROM. The author also reported the angle of ER ROM was 105° and the angle of IR ROM was 63° (8). Another study performed in Turkey, Baltacı et al. concluded that both dominant and non-dominant shoulders of baseball pitchers had greater ROM in ER and lesser ROM in IR than position players (108). According to the article reporting injuries in WP players, possible mechanism of GHJ laxity during throwing may lead to reduce IR ROM and increase ER ROM values of WP players. For this reason, shoulder rotator muscles play a critical role in providing mobility as well as stability of the GHJ in WP players during matches and training (7).

In the present study, the mean values IR ROM of WP players were lower in dominant shoulders compared to the non-dominant shoulders and ER ranges were higher in dominant shoulders compared to the non-dominant (Table 4.5). Elliott also reported that reduced medial rotation and increased lateral rotation values in dominant shoulder compared to the non-dominant shoulder (44). Witver et al. evaluated shoulder medial and lateral rotation ROM using goniometer and they reported that the ER ranges of WP players were higher on the dominant side than the non-dominant side (56). WP players may have gained ER ROM due to the biomechanics of repetitive throwing and shooting. According to Dwelly's article, collegiate overhead- throwing athletes had high ER ROM on the dominant shoulders (109). Donatelli et al. found that the throwing arms of professional baseball pitchers had a higher passive ER ROM than the non-throwing arms and they also obtained lower values on IR ROM of throwing arms (110). In contrast to WP players and baseball pitchers, studies have found that bilaterally and symmetrically decreased in glenohumeral IR and increased in ER among swimmers (56, 111 ,112). Downar et al. reported that baseball players develop unilateral adaptive changes in shoulder mobility of their throwing shoulder. According to the study, unilateral adaptive changes were explained as increased scapular upward rotation, decreased IR with increased shoulder rotation (symmetrical total motion arc), decreased shoulder capsule flexibility (113). As far as we know, since there are few studies investigating the glenohumeral IR/ ER ROM in WP players, Witwer et al. attributed these results to adaptive changes in repetitive overhead activities (56). The other possible reason for adaptations of GHJ in WP players may be related with excessive training since early ages. In the literature, adaptive changes in scapula, shoulder capsule and GHJ are defined as predisposing factors for capsular problems and shoulder injuries among overhead athletes, especially in baseball pitchers, swimmers and WP players (5, 56, 113).

According to our study, WPG had a reduced flexibility of posterior shoulder capsule compared to N-WPG (Table 4.2). Besides, posterior shoulder flexibility of dominant sides among WP players were lower compared to non-dominant sides (Table 4.5). Borstad et al. and Laudner et al. reported that repetitive throwing movement resulting in scapular adaptations in overhead throwing athletes may cause a decrease in pectoralis minor muscle length progressing to PST. Decrease in posterior shoulder capsule flexibility may be considered to be in relation with reduced IR (114, 115).

Additionally, in our study, the mean values of pectoralis minor flexibility were found to be lower in WPG than N-WPG (Table 4.2). That is to say, pectoralis minor muscles were short among WPG. Tate et al. have shown that reduced pectoralis-minor length may cause altered scapular kinematics and kyphotic posture among WP players (116). Escamilla also reported that scapular muscle imbalance resulting from reduced pectoralis minor length may lead to dyskinesis (117). Reduction of pectoralis minor length, increased scapular upward rotation were explained as risk factors for shoulder injuries (5, 69).

The most common injuries in swimmers and baseball pitchers have been shown to occur in the upper extremity due to repetitive stress on the shoulder (117, 5). Although the unique technique of swimmers and WP players is considered to be different, the study on posture profile has shown that kinematics of swimming very similar in both sports (9). Player postures and sports demands are considered to be a predisposing factor for shoulder injuries in water polo players (5). Therefore, we may consider decrease in flexibility of the pectoralis minor muscle as poor posture.

According to our results, shoulder IR and ER strength of WPG were significantly higher than N-WPG (Tablo 4.6). The mean IR strength values of the WPG were 129 N.m , whereas it was 71 N.m. in N-WPG. Additionally, the mean values of ER strength in WPG were 104.5 N.m and the mean ER strength values of the N-WPG were 61.5 N.m. In a systematic review, WP players demonstrated increased shoulder IR and ER strength compared to gender matched controls (5). Previous studies indicated that IR and ER shoulder strength measurements in professional baseball players using hand-held dynamometry and isokinetic device (118, 119, 120). In our study, we also evaluated strength measurements using hand held dynamometer. Therefore, we could not give an exact ratio like studies using isokinetic device. Tsekouras et al. also evaluated shoulder rotator strength of elite WP players using hand-held dynamometer. Unlike our study, study of McMaster et al. used an isokinetic device in shoulder strength evaluations and they found shoulder rotator strength of WP players were higher than the controls group. Similar to McMaster' study results, Tsekouras et al. reported the shoulder strength values of WP players were higher compared to control group as the same age (42). Studies reported that there may be imbalance in the rotator cuff muscles due to greater IR strength than development of ER strength in WP players (42, 121).

In our present study, shoulder IR and ER strength of WPG were found to be higher in dominant shoulders compared to non-dominant shoulders (Table 4.8). Throwing shoulder of WPG were stronger than non-throwing side. According to Devine's study, the author found shoulder IR and ER strength values of WP players in dominant side were stronger than non-dominant side (8). Donatelli et al. reported that shoulder IR and ER strength values of professional male baseball players evaluated using hand-held dynamometer found to be high on the dominant side (110). Therefore, our results were consistent with the recent literature. Since WP players unilaterally perform repetitive and forceful Abd and ER of GHJ, the rotator strength parameters on throwing side may increase due to this ability.

Our results of the study showed that there were statistically significant differences between WPG and N-WPG in terms of the trunk muscle endurance (flexor, lateral and extansor), and core stability. (Table 4.9), (Table 4.10). According to mean values, flexor and extensor muscles endurance (90.82±17.46, 56.63±13.86) in WP were higher than N-WPG (55.92± 21.80, 32.34 ± 11.00). Extensor muscle endurance of WPG was lower than the endurance of lateral and flexor muscles (Table 4.9). As far as we know, no studies published that evaluated core endurance and stability among WP players. A prospective study about overhead throwing athletes reported they need muscular endurance producing power for a long period of time (122**).** Therefore, study evaluating core stability in throwing athletes with and without shoulder pain have shown that endurance deficit of the trunk lateral flexors may lead to increase the risk of shoulder pain among throwing athletes (27). Case control and cohort studies in swimmers supported the relationship between upper extremity injuries and deficiency of core stability (123, 102) Pogetti et al. believed that poor core strength and endurance may affect to malposition of the upper extremity (27). Akuthota et al have suggested that strength, power, endurance and neuromuscular control may be important to provide core stability during sportive activities (124). Besides, McCurdy’s study about sports performance perspective showed that greater core stability may provide a foundation for greater force production in the upper and lower extremities (125). According to Kaur et al., poor core endurance may result in lack of force transmission generated between the lower and the upper extremity

(126). Studies with professional baseball picthers showed that rectus abdominis muscles is mostly activated just before ball release while that extansor muscles on the contralateral side of the throwing arm were more active during the cocking phase. Hiroshima et al. considered these muscles to be a very effective for the generation of high force and energy in the trunk for throwing (127).

In the current literature, unlike ground-based sports, in sports which include swimming, the CR may considered as reference point for all movements (24). Greater core stability could be particularly beneficial for WP players to allow efficient transfer of force between the trunk and the upper. Additionally, it may provide to keep their body above water using EBK.

Our study has some limitations.

- Although pre-performed power analysis before the initiation of the research indicated a number of 80 participants, and even though our study group is larger than that still it will be more stronger if the study group was larger.
- Lack of normative data in the literature lead to requirement of larger sample size.
- Shoulder injuries in female players are seen more frequent compared to male players, therefore if women were included in the study population a stronger study would have been achieved.
- If shoulder strength evaluations were performed using isokinetic device, IR/ER strength ratio would be found more objectively.

6. CONCLUSION AND SUGGESTIONS

In conclusion, this study showed that shoulder joint and core (trunk) parameters of WPG differ from N-WPG and these results may be considered as risk factors for frequent shoulder problems. As far as we know, there are no studies developing exercise program to prevent shoulder injuries among WP players. It was thought that the water polo-specific preventive exercise program, which has been applied since early ages, may reduce the possibility of injury to athletes in their sports life.

Current literature reveals, although the mechanism in baseball pitchers and swimmers is considered as different from WP players, the decreasing IR ROM values of these athletes may be attributed to increased ER ROM values. Therefore, it may be advisable to follow the injury incidence and pain profiles of athletes who have adaptations in rotation ranges. However, it is unclear at what point these observed ROM changes are predisposing factors to shoulder injury in WP players.

Furthermore, reduced proprioception may cause a delayed neuromuscular protective reflex, the result in contraction of shoulder rotator muscle may be inadequate to preserve the excessive movement of the joint. It can be thought that adaptations in the capsule and muscles may be affected not only by biomechanics but also by proprioceptive senses. Therefore, the relationship between joint proprioception and muscle strength should also be studied.

Adaptations in mobility of the shoulder which result from the repetitive overhead activities like throwing and swimming may lead to shoulder injuries in water polo. Future implications for research may include assessment of scapular dyskinesia and posture to prevent sports specific muscular adaptations. Additionally, the relationship between IR/ER strength ratio and risk of injury may be evaluated pre-seasonly. Throwing speed may be monitored among WP players with desired IR/ER shoulder strength ratio in order to determine performance expectations.

It should be recommended that all parameters of the CR should be given importance for the athletes in water sports to beat their feet for a long time and to transfer the force generated from the lower extremity to the upper extremity. By adding trunk endurance exercises to their training programs, they may maintain the vertical position during the match and may cope with fatigue during match. Besides, future research should seek to establish core stability test batteries that includes dynamic muscle actions during sport participation, consistent with the core stability components. However, further studies are needed to support these hypotheses.

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APPENDIX 1: ETHICAL COMMITTEE APPROVAL

T.C. YEDİTEPE ÜNİVERSİTESİ

Sayı : 37068608-6100-15- 1629
Konu: Klinik Araştırmalar
Etik kurul Başvurusu hk.

12/03/2019

İlgili Makama (Aslı Yeral)

Yeditepe Üniversitesi Hastanesi Ortopedi ve Travmatoloji Anabilim Dalı Prof. Dr. Uğur Şaylı'nın sorumlu olduğu **"Sutopu Oynayan Sporcularda Omuz Ekleminin ve 'Core' Stabilitenin Değerlendirilmesi"** isimli araştırma projesine ait Klinik Araştırmalar Etik Kurulu (KAEK) Başvuru Dosyası (**1600** kayıt Numaralı KAEK Başvuru Dosyası), Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından **11.03.2019** tarihli toplantıda incelenmiştir.

Kurul tarafından yapılan inceleme sonucu, yukarıdaki isimi belirtilen çalışmanın yapılmasının etik ve bilimsel açıdan uygun olduğuna karar verilmiştir (**KAEK Karar No: 981**).

Prof. Dr. Turgay ÇELİK
Yeditepe Üniversitesi
Klinik Araştırmalar Etik Kurulu Başkanı

Yeditepe Üniversitesi 26 Ağustos Yerleşimi, İnönü Mahallesi Kayışdağı Caddesi 34755 Ataşehir / İstanbul
T. 0216 578 00 00 www.yeditepe.edu.tr F. 0216 578 02 99

APPENDIX 2: INFORMED WRITTEN CONSENT

BİLGİLENDİRİLMİŞ GÖNÜLLÜ OLUR FORMU

Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Spor Fizyoterapisi Anabilim Dalı, Yüksek Lisans Tezi kapsamında, **sutopu oyuncularında** omuz ekleminin ve çevresi kaslarının değerlendirilmesini ve omuz yaralanma risklerine etki eden faktörlerin araştırılmasını planlamaktayız. Araştırmanın başlığı, **"SUTOPU OYNAYAN SPORCULARDA OMUZ EKLEMİNİN VE 'CORE' STABİLİTENİN DEĞERLENDİRİLMESİ" dir.**

Çalışmaya katılım gönüllülük esasına dayalıdır. Katılmak isteyip istemediğinize karar vermeden önce araştırmanın neden ve nasıl yapılacağını, bilgilerinizin nasıl kullanılacağını ve çalışmanın neleri içerdiğini anlamanız önemlidir. Lütfen aşağıdaki bilgileri dikkatlice okumak için zaman ayırınız. Eğer anlamadığınız ve sizin için açık olmayan şeyler varsa ya da daha fazla bilgi almak isterseniz lütfen bize sorunuz. Kararınızdan önce araştırma hakkında sizi bilgilendirmek istiyoruz. Bu bilgileri okuyup anladıktan sonra araştırmaya katılmak isterseniz formu imzalayınız.

Araştırmaya davet edilmenizin nedeni; **sutopu ile düzenli olarak ilgilenen sporcular** ve herhangi bir başüstü aktivite içeren spor (Ör: su topu, yüzme vs.) ile **düzenli olarak ilgilenmeyenler kişilerde** omuz ekleminin stabilizasyonu ve omurgayı destekleyen kasların dayanıklılık durumlarını karşılaştırmaktır. Bu amaçla her iki grubu değerlendirmek ve ilişkili durumları araştırmak üzere bu çalışma gerçekleştirilecektir.

Eğer araştırmaya katılmayı kabul ederseniz Prof. Dr. Uğur ŞAYLI ve Fzt. Aslı YERAL tarafından değerlendirmeleriniz yapılacak ve bulgular kaydedilecektir. Araştırma kapsamında, sizin sağlık durumunuza ilişkin bazı tanıtıcı sorulara cevap vermeniz istenecek ve size girişimsel olmayan, uygularken canınızı acıtmayacak 7 adet fiziksel değerlendirme uygulanacaktır. Araştırmada yapılan değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmada kullanılacaktır. Bu amaçların dışında bu kayıtlar kullanılmayacak ve başkalarına verilmeyecektir. Araştırma bir kongrede ya da dergide yayın olarak kabul edilse bile sizin kimliğinizi ortaya çıkarabilecek kayıtlar gizli tutulacaktır.

Değerlendirme Yöntemleri

- **Omuz çevresi kaslarının uzayabilme/esneyebilme özelliklerinin değerlendirilmesi:** Katılımcı sırtüstü pozisyondayken, omuz kaslarının esnekliği mezura ile ölçülecektir.
- **Omuz ekleminin esnekliğinin değerlendirmesi:** Katılımcı sırtüstü pozisyondayken açıölçer ile ölçüm alınarak omuz ekleminin esnekliği değerlendirilecektir.
- **Omurganın ön, arka ve yan grup kaslarının dayanıklılık testleri:** Bu testlerde omurganın ön, arka ve yan grup kaslarının dayanıklılıkları, katılımcıların farklı pozisyonları koruyabilme süreleri kayıt edilecektir. Süreler kronometre kullanılarak değerlendirilecektir.
- **Omuz Ekleminin İç ve Dış Rotasyon Eklem Hareket Açıklığı Değerlendirilmesi:** Katılımcı sırtüstü pozisyondayken, omuz ekleminin iç ve dış rotasyon eklem hareket açıklığı açı ölçer ile değerlendirilecektir.
- **Omuzda Bulunan Rotator Manşet Kaslarının Kuvvet Değerlendirilmesi:** Rotator manşet kaslarının kuvvet değerlendirilmesi katılımcı sırtüstü pozisyondayken, kas kuvvetini ölçen el dinamometresi (miyometre) cihazı ile yapılacaktır.
- **Kalça ve bel bölgesi kaslarının (CORE) stabilizasyonun değerlendirilmesi:** Katılımcı sırtüstü pozisyondayken, bel bölgesi ile yatak arasına özel bir basınç ölçen cihaz yerleştirilecek, katılımcının belirlenen hareketleri istenilen basınç seviyesinde sürdürebilme süreleri kronometre ile kayıt edilecektir.

Bu çalışma ile sutopu oynayan ve sutopu oynamayan kişilerde, omuz eklemi ve “core “stabilite değerlendirilecek ayrıca omuz eklemi ve core stabilite arasındaki ilişki araştırılacaktır.

SORUMLU ARAŞTIRMACI: Prof. Dr. Uğur ŞAYLI - Fzt. Aslı YERAL

İLETİŞİM: 0537 965 84 94

Bilgilendirilmiş gönüllü olur formundaki tüm açıklamaları okudum. Bana yukarıdaki konusu ve amacı belirtilen araştırma ile ilgili yazılı ve sözlü açıklama aşağıda adı belirtilen kişi tarafından yapıldı. **"SUTOPU OYNAYAN SPORCULARDA OMUZ EKLEMİNİN VE 'CORE' STABİLİTENİN DEĞERLENDİRİLMESİ"** adlı bu çalışmaya hiçbir baskı ve zorlama olmaksızın kendi rızamla katılmayı kabul ediyorum.

Kişinin;

Adı, Soyadı:

Telefon:

İmza:

Tarih:

Açıklamaları Yapan Kişinin;

Adı, Soyadı:

Adres:

İmza:

Tarih:

APPENDIX 3: PARENT INFORMED WRITTEN CONSENT

ÇALIŞMA GRUBU İÇİN BİLGİLENDİRİLMİŞ EBEVEYN/AİLE OLUR FORMU

Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Spor Fizyoterapisi Anabilim Dalı, Yüksek Lisans Tezi kapsamında, **sutopu oyuncularında** omuz ekleminin ve çevresi kaslarının değerlendirilmesini ve omuz yaralanma risklerine etki eden faktörlerin araştırılmasını planlamaktayız. Araştırmanın başlığı, **"SUTOPU OYNAYAN SPORCULARDA OMUZ EKLEMİNİN VE 'CORE' STABİLİTENİN DEĞERLENDİRİLMESİ" dir.**

Çalışmaya katılım gönüllülük esasına dayalıdır. Çocuğunuzun çalışmaya katılmasını isteyip istemediğinize karar vermeden önce araştırmanın neden ve nasıl yapılacağını, çocuğunuzu bilgilerinin nasıl kullanacağını ve çalışmanın neleri içerdiğini anlamanız önemlidir. Lütfen aşağıdaki bilgileri dikkatlice okumak için zaman ayırınız. Eğer anlamadığınız ve sizin için açık olmayan şeyler varsa ya da daha fazla bilgi almak isterseniz lütfen bize sorunuz. Kararınızdan önce araştırma hakkında sizi bilgilendirmek istiyoruz. Bu bilgileri okuyup anladıktan sonra araştırmaya katılmak isterseniz formu imzalayınız.

Çocuğunuzun araştırmaya davet edilmesinin nedeni; **sutopu ile düzenli olarak ilgilenen sporcularda** tekrarlı omuz problemlerinin ve omuz ağrısının sıklıkla görülebilmesidir. Omurgayı destekleyen kasların dayanıklılığı ve kuvvetindeki yetersizlikler de sutopu oynayan sporcuların yaralanmalarına neden olabilmektedir. Bu problemleri açıklayabilmek, omuz yaralanmalarının muhtemel risk faktörlerini ve ilişkili durumları araştırmak üzere bir çalışma gerçekleştirilecektir.

Eğer araştırmaya katılmayı kabul ederseniz Prof. Dr. Uğur ŞAYLI ve Fzt. Aslı YERAL tarafından değerlendirmeleriniz yapılacak ve bulgular kaydedilecektir. Araştırma kapsamında, çocuğunuzdan sağlık durumu ile ilgili bazı tanıtıcı sorulara cevap vermesi istenecek ve çocuğunuza girişimsel olmayan, uygularken canını acıtmayacak 7 adet fiziksel değerlendirme uygulanacaktır. Araştırmada yapılan değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmada kullanılacaktır. Bu amaçların dışında bu kayıtlar kullanılmayacak ve başkalarına verilmeyecektir. Araştırma bir kongrede ya da dergide yayın olarak kabul edilse bile çocuğunuzun kimliğini ortaya çıkarabilecek kayıtlar gizli tutulacaktır.

Değerlendirme Yöntemleri

- **Omuz çevresi kaslarının uzayabilme/esneyebilme özelliklerinin değerlendirilmesi:** Katılımcı sırtüstü pozisyondayken, omuz kaslarının esnekliği mezura ile ölçülecektir.
- **Omuz ekleminin esnekliğinin değerlendirmesi:** Katılımcı sırtüstü pozisyondayken açıölçer ile ölçüm alınarak omuz ekleminin esnekliği değerlendirilecektir.
- **Omurganın ön, arka ve yan grup kaslarının dayanıklılık testleri:** Bu testlerde omurganın ön, arka ve yan grup kaslarının dayanıklılıkları, katılımcıların farklı pozisyonları koruyabilme süreleri kayıt edilecektir. Süreler kronometre kullanılarak değerlendirilecektir.
- **Omuz Ekleminin İç ve Dış Rotasyon Eklem Hareket Açıklığı Değerlendirilmesi:** Katılımcı sırtüstü pozisyondayken, omuz ekleminin iç ve dış rotasyon eklem hareket açıklığı açı ölçer ile değerlendirilecektir.
- **Omuzda Bulunan Rotator Manşet Kaslarının Kuvvet Değerlendirilmesi:** Rotator manşet kaslarının kuvvet değerlendirilmesi katılımcı sırtüstü pozisyondayken, kas kuvvetini ölçen el dinamometresi (miyometre) cihazı ile yapılacaktır.
- **Kalça ve bel bölgesi kaslarının (CORE) stabilizasyonun değerlendirilmesi:** Katılımcı sırtüstü pozisyondayken, bel bölgesi ile yatak arasına özel bir basınç ölçen cihaz yerleştirilecek, katılımcının belirlenen hareketleri istenilen basınç seviyesinde sürdürebilme süreleri kronometre ile kayıt edilecektir.

Bu çalışma ile sutopu oynayanlarda omuz eklemi ve “core “stabilite değerlendirilecek ayrıca omuz eklemi ve core stabilite arasındaki ilişki araştırılacaktır.

SORUMLU ARAŞTIRMACI: Prof. Dr. Uğur ŞAYLI - Fzt. Aslı YERAL
İLETİŞİM: 0537 965 84 94

"SUTOPU OYNAYAN SPORCULARDA OMUZ EKLEMİNİN VE 'CORE' STABİLİTENİN DEĞERLENDİRİLMESİ" adlı bu çalışmaya velisi olduğum .... isimli çocuğumun hiçbir baskı ve zorlama olmaksızın katılabileceğini beyan ederim.

Velinin;	Açıklamaları Yapan Kişinin;
Adı, Soyadı:	**Adı, Soyadı:**
Telefon:	**Adres:**
İmza:	**İmza:**
Tarih:	**Tarih:**

KONTROL GRUBU İÇİN BİLGİLENDİRİLMİŞ EBEVEYN/AİLE OLUR FORMU

Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Spor Fizyoterapisi Anabilim Dalı, Yüksek Lisans Tezi kapsamında, omuz çevresi ve omurgayı destekleyen kasların dayanıklılıklarının normal değerlerinin araştırılmasını planlamaktayız. Araştırmanın başlığı, **"SUTOPU OYNAYAN SPORCULARDA OMUZ EKLEMİNİN VE 'CORE' STABİLİTENİN DEĞERLENDİRİLMESİ" dir.**

Çalışmaya katılım gönüllülük esasına dayalıdır. Çocuğunuzun çalışmaya katılmasını isteyip istemediğinize karar vermeden önce araştırmanın neden ve nasıl yapılacağını, çocuğunuzun bilgilerinin nasıl kullanacağını ve çalışmanın neleri içerdiğini anlamanız önemlidir. Lütfen aşağıdaki bilgileri dikkatlice okumak için zaman ayırınız. Eğer anlamadığınız ve sizin için açık olmayan şeyler varsa ya da daha fazla bilgi almak isterseniz lütfen bize sorunuz. Kararınızdan önce araştırma hakkında sizi bilgilendirmek istiyoruz. Bu bilgileri okuyup anladıktan sonra araştırmaya katılmak isterseniz formu imzalayınız.

Çocuğunuzun araştırmaya davet edilmesinin nedeni; **sutopu ile düzenli olarak ilgilenen sporcularda** ve herhangi bir başüstü aktivite içeren spor (Ör: su topu, yüzme vs.) ile **düzenli olarak ilgilenmeyen kişilerde** omuz ekleminin stabilizasyonu ve omurgayı destekleyen kasların dayanıklılık durumlarını karşılaştırmaktır. Bu amaçla her iki grubu değerlendirmek ve ilişkili durumları araştırmak üzere bu çalışma gerçekleştirilecektir.

Eğer araştırmaya katılmayı kabul ederseniz Prof. Dr. Uğur ŞAYLI ve Fzt. Aslı YERAL tarafından değerlendirmeleriniz yapılacak ve bulgular kaydedilecektir. Araştırma kapsamında, çocuğunuzdan sağlık durumu ile ilgili bazı tanıtıcı sorulara cevap vermesi istenecek ve çocuğunuza girişimsel olmayan, uygularken canınızı acıtmayacak 7 adet fiziksel değerlendirme uygulanacaktır. Araştırmada yapılan değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmada kullanılacaktır. Bu amaçların dışında bu kayıtlar kullanılmayacak ve başkalarına verilmeyecektir. Araştırma bir kongrede ya da dergide yayın olarak kabul edilse bile çocuğunuzun kimliğini ortaya çıkarabilecek kayıtlar gizli tutulacaktır.

Değerlendirme Yöntemleri

- **Omuz çevresi kaslarının uzayabilme/esneyebilme özelliklerinin değerlendirilmesi:** Katılımcı sırtüstü pozisyondayken, omuz kaslarının esnekliği mezura ile ölçülecektir.
- **Omuz ekleminin esnekliğinin değerlendirmesi:** Katılımcı sırtüstü pozisyondayken açıölçer ile ölçüm alınarak omuz ekleminin esnekliği değerlendirilecektir.
- **Omurganın ön, arka ve yan grup kaslarının dayanıklılık testleri:** Bu testlerde omurganın ön, arka ve yan grup kaslarının dayanıklılıkları, katılımcıların farklı pozisyonları koruyabilme süreleri kayıt edilecektir. Süreler kronometre kullanılarak değerlendirilecektir.
- **Omuz Ekleminin İç ve Dış Rotasyon Eklem Hareket Açıklığı Değerlendirilmesi:** Katılımcı sırtüstü pozisyondayken, omuz ekleminin iç ve dış rotasyon eklem hareket açıklığı açı ölçer ile değerlendirilecektir.
- **Omuzda Bulunan Rotator Manşet Kaslarının Kuvvet Değerlendirilmesi:** Rotator manşet kaslarının kuvvet değerlendirilmesi katılımcı sırtüstü pozisyondayken, kas kuvvetini ölçen el dinamometresi (miyometre) cihazı ile yapılacaktır.
- **Kalça ve bel bölgesi kaslarının (CORE) stabilizasyonun değerlendirilmesi:** Katılımcı sırtüstü pozisyondayken, bel bölgesi ile yatak arasına özel bir basınç ölçen cihaz yerleştirilecek, katılımcının belirlenen hareketleri istenilen basınç seviyesinde sürdürebilme süreleri kronometre ile kayıt edilecektir.

Başüstü aktivite içeren spor ile düzenli olarak ilgilenmeyen kişilerde omuz eklemi ve “core” stabilite değerlendirilecek ayrıca omuz eklemi ve core stabilite arasındaki ilişki araştırılacaktır.

SORUMLU ARAŞTIRMACI: Prof. Dr. Uğur ŞAYLI - Fzt. Aslı YERAL

İLETİŞİM: 0537 965 84 94

"SUTOPU OYNAYAN SPORCULARDA OMUZ EKLEMİNİN VE 'CORE' STABİLİTENİN DEĞERLENDİRİLMESİ" adlı bu çalışmaya velisi olduğum .... isimli çocuğumun hiçbir baskı ve zorlama olmaksızın katılabileceğini beyan ederim.

Velinin;

Adı, Soyadı:

Telefon:

İmza:

Tarih:

Açıklamaları Yapan Kişinin;

Adı, Soyadı:

Adres:

İmza:

Tarih:

APPENDIX 4: EVALUATION CHART

Adı Soyadı:

ESNEKLİK VE KUVVET:

	1.ÖLÇÜM		2.ÖLÇÜM		ORT.	
	SAĞ	SOL	SAĞ	SOL	SAĞ	SOL
Pektoralis Majör Klavikular Parçası Uzunluk (cm):						
Pektoralis Majör Sternal Parçası Uzunluk (cm):						
Pektoralis Minör Kası Uzunluk (cm):						
Arka Kapsül Esneklik Değerlendirmesi (derece):						
	1.DENEME		2.DENEME		ORT.	
	SAĞ	SOL	SAĞ	SOL	SAĞ	SOL
İç Rotasyon Kuvvet ölçümü (N.m):						
Dış Rotasyon Kuvvet Ölçümü (N.m):						

ROM ÖLÇÜMÜ:

	SAĞ	SOL
IR(derece)		
ER(derece)		

SKAPULA MESAFESİ (cm)		

GÖVDE DAYANIKLILIK:

FLEKSÖR				YAN GRUP								EKSTANSÖR			
				SAĞ				SOL							
1	2	3	ORT.	1	2	3	ORT.	1	2	3	ORT.	1	2	3	ORT.
			sn												

CORE STABİLİTE:

SEVİYE 1/2	SEVİYE 1	SEVİYE 2	SEVİYE 3	SEVİYE 4	SEVİYE 5	TOPLAM

APPENDIX 5: STRUCTURED QUESTIONNAIRE

YEDİTEPE ÜNİVERSİTESİ

Yeditepe Üniversitesi

Sağlık Bilimleri Enstitüsü

Spor Fizyoterapisi Anabilim Dalı

DEĞERLENDİRME FORMU

Tarih: …/….. /….

Ad Soyad: Telefon:
Doğum Tarihi: Cinsiyet: ( ) Kadın ( ) Erkek Boy (cm): ....
Kilo (kg): .... BKI (kg)/m²): .... Dominant El: ( ) Sağ ( ) Sol

✓ Kronik bir hastalığınız var mı?
( ) Yok ( ) Solunum Problemleri
( ) Ortopedik Problemler ( ) Nörolojik problemler
( ) Travma ( ) Diğer.........................

✓ Ameliyat geçirdiniz mi? ( ) Evet ( ) Hayır

✓ Ne ameliyatı?...................

✓ Sakatlanma yaşadınız mı? ( ) Evet ( ) Hayır

✓ Hangi bölgenin sakatlandığını belirtiniz.
( ) Baş-boyun ( ) Omuz ( ) Bel Bölgesi ( ) Kalça
( ) Dirsek ( ) El Bileği ( ) Diz ( ) Ayak bileği

✓ Sakatlanmanın yıl(ları) yazınız …………,...........

✓ Omuz ve omuz çevresinde kırık ya da çıkık yaşadınız mı? ( ) Evet ( ) Hayır

✓ Omuz ile ilgili tedavi gördünüz mü? ( ) Evet ( ) Hayır

✓ Omuzda kronik bir ağrınız var mı? ( ) Evet ( ) Hayır

- ✓ Kronik bir ağrınız var mı? ( ) Evet ( ) Hayır
- ✓ Bölgesi? ……………
- ✓ Düzenli yaptığınız spor var mı? ( ) Evet ( ) Hayır
- ✓ Sporun adı? ………………
- ✓ Kaç yıldır yapmaktasınız? …………………..
- ✓ Haftalık antrenman sıklığınız nedir?

( ) Haftada 1 kez ( ) Haftada 2-3kez ( ) Haftada 4-5 kez ( ) Her gün

- ✓ Yaptığınız antrenman ortalama kaç dakika sürüyor?

( ) 30 – 60 dk ( ) 60 – 90 dk ( ) 90 – 120 dk

- ✓ Sezon boyunca ortalama kaç maça çıkıyorsunuz?

( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5

- ✓ Yapmakta olduğunuz spor **sutopu ise**; antrenmanda tahmini olarak ortalama kaç atış yapmaktasınız? …………………..
- ✓ Antrenman öncesi ve sonrasında düzenli ısınma ve soğuma yapıyor musunuz? ( ) Evet ( ) Hayır

TEŞEKKÜR EDERİZ.

APPENDIX 6: ÖZGEÇMİŞ

KİŞİSEL BİLGİLER		
Akademik Ünvanı	**Lisans Üstü Bursiyer (Asistan)**	
Ad – Soyad	**ASLI YERAL**	
Doğum Yeri	**İSKENDERUN**	
Doğum Tarihi	**11.09.1994**	
E-Posta Adresi	**a.yeral@hotmail.com**	-

EĞİTİM BİLGİLERİ	
Profesörlük Bilgileri	
Profesörlük Kadrosuna Atanma Tarihi:	
Profesörlük Kadrosuna Atandığı Üniversite Adı :	Bulunduğu Şehir /Ülke:
Doçentlik Bilgileri	
Doçentlik Belgesini Aldığı Tarih:	
Doçentlik Kadrosuna Atandığı Üniversite Adı :	Bulunduğu Şehir /Ülke:
Doçentlik Kadrosuna Atanma Tarihi :	
Doktora - Tıpta Uzmanlık Bilgileri	
Üniversite / Tıpta Uzmanlık Eğitimini Aldığı Hastane Adı:	Bulunduğu Şehir /Ülke:
Bölüm /Anabilim Dalı Adı:	
Not Ortalaması:	Mezuniyet Tarihi:
Yüksek Lisans Bilgileri	
Üniversite Adı: **Yeditepe Üniversitesi**	Bulunduğu Şehir /Ülke: **İSTANBUL/TÜRKİYE**
Bölüm Adı: **Spor Fizyoterapisi**	
Not Ortalaması: **3.83**	Mezuniyet Tarihi: **öğrenim devam etmekte**
Lisans Bilgileri	
Üniversite Adı: **Yeditepe Üniversitesi**	Bulunduğu Şehir /Ülke: İSTANBUL/TÜRKİYE
Bölüm Adı: **Fizyoterapi ve Rehabilitasyon**	
Not Ortalaması: **3.37**	Mezuniyet Tarihi: **2017**
Lise Bilgileri	

Okul Adı: **İKEM Anadolu Lisesi**	Bulunduğu Şehir /Ülke: **HATAY/TÜRKİYE**
Bölüm Adı: **Fen Bilimleri**	
Not Ortalaması: -	Mezuniyet Tarihi: **2012**
Ortaokul / İlköğretim Okul Bilgileri	
Okul Adı: -	Bulunduğu Şehir /Ülke:
Not Ortalaması: -	Mezuniyet Tarihi: -
İlkokul Bilgileri	
Okul Adı: -	Bulunduğu Şehir /Ülke: -
Not Ortalaması:	Mezuniyet Tarihi: -
İŞ DENEYİMLERİ	
1. İş Deneyimi	
Çalışılan Kurum Adı: **Yeditepe Üniversitesi**	Bulunduğu Şehir /Ülke: **İSTANBUL/TÜRKİYE**
Kurumdaki Ünvanınız/ Göreviniz: **Fizyoterapist / Lisansüstü Bursiyer (Asistan)**	
Çalışma Şekli:	
İşe Başlama Tarihiniz: **2017**	İşten Ayrılma Tarihiniz:
İşten Ayrılış Nedeniniz :	
SAHİP OLUNAN SERTİFİKA BİLGİLERİ	
1.Sertifika Adı : Musculoskeletal Skills for The Pregnancy, Post Natal, Women's & Pelvic Health Physiotherapist	
Sertifika Alınan Kurum/ Üniversite Adı : Gerard GREENE MSc (Manip Physio), MMACP, PGCert Hed	
Sertifika Yılı : 2018	
2.Sertifika Adı : Day 1 An Introduction to urinary incontinance / Day 2 Advance incontinence-bladder & bowel dysfunction	

Sertifika Alınan Kurum/ Üniversite Adı : Lisa HASTIE BSC (Hons), MCSP, SRP, PGC Cont Specialist Pelvic Health Physiotherapist U.K.
Sertifika Yılı : 2018
3.Sertifika Adı : Alexander-Technique Intense Workshop Course
Sertifika Alınan Kurum/ Üniversite Adı : Matthias GRAEFEN
Sertifika Yılı : 2018
4.Sertifika Adı : Ante-Postnatal Pilates
Sertifika Alınan Kurum/ Üniversite Adı : Australian Physiotherapy & Pilates Institute (APPI)
Sertifika Yılı : 2018
5.Sertifika Adı : MODİFİYE MATWORK LEVEL 3 PİLATES KURSU
Sertifika Alınan Kurum/ Üniversite Adı : Australian Physiotherapy & Pilates Institute (APPI)
Sertifika Yılı : 2017
6.Sertifika Adı : MODİFİYE MATWORK LEVEL 1 PİLATES KURSU
Sertifika Alınan Kurum/ Üniversite Adı : Australian Physiotherapy & Pilates Institute (APPI)
Sertifika Yılı: 2017

BİLİMSEL YAYINLARINIZ , ESERLERİNİZ VE ÇALIŞMALARINIZ
Şaylı U., Demirbaş Ş., Subaşı F., Akbuğa E., Çil E.T., Akyol T., Biros J., Yeral A. "Chronic Ankle Instability and Associated Factors: Preliminary Data Of A Cross Sectional Study"

HAKİM OLDUĞUNUZ BİLGİSAYAR PROGRAMLARI
Microsoft Office, SPSS, Mendeley

REFERANSLAR
Ad-Soyad: Prof. Dr. Feryal SUBAŞI **Şirket - Unvan - İş Pozisyonu: Yeditepe Üniversitesi- Profesör Dr.- Bölüm Başkanı** **Telefon Numarası: 0533 275 9595**

Ad-Soyad: Prof. Dr. Rasmi MUAMMER
Şirket - Unvan - İş Pozisyonu: Yeditepe Üniversitesi – Dekan Yardımcısı
Telefon Numarası: 0505 650 2827