SHOULDER PROPRIOCEPTION IN MALE TENNIS PLAYERS BETWEEN AGES 14-16

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

SHOULDER PROPRIOCEPTION IN MALE TENNIS PLAYERS BETWEEN AGES 14-16

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Proprioceptive information appear to play an important role in stability and movements of shoulder joint in sporting activities especially in tennis. The purpose of this study was to measure the shoulder proprioceptive differences, and assess proprioceptive sense between dominant and non-dominant shoulders between male tennis players and controls between ages 14 - 16. 15 young male tennis players with a mean age 14.6 ± 0.7 years and 15 young male sedentary individuals with a mean age 14.8 ± 0.9 years participated in this cross-sectional descriptive study. Average height, weight, and BMI of the players were 169.4 ± 5.9 cm., 63.9 ± 5.5 kg., and 22.2 ± 1.0 kg/m^2 respectively. Mean height, weight, and BMI of the non-players were 168.3 ± 5.3

cm., 64.4 ± 10.2 kg., and 23.1 ± 3.9 kg/m^2 respectively. Proprioceptive sense was measured with an isokinetic dynamometer. Measurements were made in two positions: 'sitting' versus 'standing' for service, forehand, and backhand positions. Differences between players and control groups were investigated by MANOVA. Paired t-test was used to evaluate differences between dominant and non-dominant shoulders and sitting and standing positions. There was no statistically difference between players and non-players in means of age, body height, weight, and BMI. The study revealed the following results: 1) There was a significant difference between shoulder proprioceptive senses of players and controls ($p < 0.05$) at service, forehand, and backhand positions. 2) Significant difference between dominant and non-dominant shoulders at 15º and 30º was not observed ($p < 0.05$). 3) No significant difference was observed between sitting and standing positions at 30º ($p < 0.05$). It was concluded that tennis players had better proprioceptive sense than their age matched sedentary controls.

Key Words: Shoulder, Proprioception, Body Positions, Tennis

ÖZ

14-16 YAŞ ERKEK TENİS OYUNCULARINDA OMUZ PROPRİYOSEPSİYONU

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Yüksek Lisans, Beden Eğitimi ve Spor Bölümü

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Propriyoseptif bilginin, sportif aktivitelerde özellikle teniste omuz ekleminin stabilitesi ve hareketinde önemli rol aldığı görülmektedir. Bu çalışmanın amacı, 14 – 16 yaş arası tenis oynayan ve oynamayan kişilerin baskın olan ve baskın olmayan omuz propriyosepsiyon farklarını ölçmekti. Bu çalışmaya yaş ortalaması 14.6 ± 0.7 yıl olan 15 erkek tennis oyuncusu ile yaş ortalaması 14.8 ± 0.9 yıl olan 15 sedenter erkek katılmıştır. Oyuncuların ortalama boy, kilo, ve vücut kitle indeksi sırası ile 169.4 ± 5.9 cm., 63.5 ± 5.5 kg., ve 22.2 ± 1.0 kg/m^2 dı. Spor yapmayanların ortalama boy, kilo ve vücut kitle indeksi ise 168.3 ± 5.3 cm., 64.4 ± 10.2 kg., ve 23.1 ± 3.9 kg/m^2 dı. Propriyosepsiyon isokinetik dinamometre ile ölçüldü. Ölçümler servis, forehand, ve backhand için oturarak ve ayakta olmak üzere iki pozisyonda alındı. Oyuncular ve kontrol grubu arasındaki farklar MANOVA kullanılarak bulundu. Oturur ve ayaktaki pozisyonlarda baskın olan ve baskın olmayan omuzlar arasındaki fark ilişkili t-test kullanılarak hesaplandı. Oyuncular ve spor yapmayan kişilerin, boy, kilo ve vücut kitle indeksi ortalamalarında istatiksel olarak bir fark yoktu. Bu çalışmada aşağıdaki sonuçlar ortaya çıkmıştır: 1) Omuz propriyosepsiyonu açısından oyuncular ve kontrol grubu arasında servis, forehand ve backhand pozisyonlarında belirgin bir fark vardı ($p < 0.05$). 2) 15 ve 30 Derecelik açılarda baskın olan ve baskın olmayan omuzlar arasında önemli bir fark gözlemlenmedi ($p < 0.05$). 3) 30 Derecede oturarak ve ayakta alınan ölçümlerde belirgin bir fark yoktu ($p < 0.05$). Özet olarak, tenis oyuncularının omuz propriyosepsiyonu aynı yaştaki sedenter kişilerden daha iyidi.

Anahtar Kelimeler: Omuz, Propriyosepsiyon, Vücut Pozisyonu, Tenis

To My Wife

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CHAPTER I

INTRODUCTION

Tennis is one of the most world wide popular sports known for its challenging as well as recreational features, with number of participants increasing continiously. Birber et al. (1986) emphasized that playing the game regularly develops many physical qualities and abilities which can be useful for individuals to lead a healthy life.

The sport of tennis belongs to the group of acyclical and aperiodical physical exercises which are mostly influenced by the movements of an opponent (Seliger et al., 1973). Sport scientists and trainers agree that motor skills such as power, strength, agility, speed and explosiveness are strongly correlated with the performance of the players (König et al., 2001). Mental strength, neuromuscular coordination and ability also play important roles in performance (König et al., 2001). Tennis itself represents a long time lasting sport activity (Seliger et al., 1973). The tournament schedule of competitive tennis often requires players to perform two or even three times per day in matches, each of which may sometimes last over 3 hours (Magal et al., 2002; Vergauwen et al., 1998).

If the talents mentioned above are not improved or not present at all, the players cannot bring into play the crucial characteristics such as technique, coordination, concentration and tactics in long matches (König et al, 2001).

Mont et al. (1994) stated that ballistic motions of the upper extremity with the arm in abduction are common in the sport of tennis. It has been described that the chain of the actions causes the transfer of truncal torque to ultimate projectile velocity. The transfer of this torque ultimately depends on an explosive contraction of the shoulder muscles (Mont et al, 1994). Tennis mostly involves repeated forceful and quick overhead arm actions (e.g. service and smash) with the extended forearms. These overhead ballistic movements generate a great deal of eccentric load on the shoulder joint. Thus, the ability to elevate the hand over the head and execute many forceful functional tasks requires well coordinated and synchronized actions of shoulder muscles (Chandler et al., 1992; Kablan et al, 2004).

The game of tennis has various modern stroke techniques such as forehand, backhand, volley, service, smash, approach strokes (Segal, 2005), drop shots (Crespo and Miley, 1998) and lob (Groppel, 1992; Hoskins, 2003). However, the basic tennis strokes are service, forehand, and backhand. In the sport of tennis, the service is performed in order to put the ball in play or to start the point. A good serve can be an effective stroke helping the players win a point in the game of tennis. If it is not hit well, the opponent most probably breaks it (Groppel, 1992; Hoskins, 2003). In other words, it may determine the result of a game. In tennis, one of the most crucial strokes is forehand. In today's tennis, most advanced players choose to make strong forehand shots during the baseline rallies in order to put the opponent under pressure and gain the point (Crespo and Miley, 1998). In addition, elit players have developed their backhand strokes as a forceful shot, just like their forehand strokes (Bolettieri, 2001).

A good stroke is executed with a good technique. Bompa defined technique as the specific manner of performing a physical exercise (1999). He also stated that if a player has a perfect technique, s/he will spend less energy to achieve the desired result. Crespo and Miley (1998) pointed out that an optimum technique in tennis allows the players to combine power and control for various strokes, which reduces the risk of injury.

Unfortunately, there are so many negative factors that influence high level of technique. Some of these factors have to do with the player himself or herself. These include psychological limitation, insufficient physical preparation for improved coordination and strength, fatigue, mental and moral limitation, lack of self-confidence and fear of injuries, interference of a new skill acquisition with the skills that already exist, incorrect grasping of an object or apparatus and mispresenting a technical pattern of a skill due to muscular desensation.

Carello and Turvey (2004) stated that sense is tied to receptors that are found in muscles, tendons and ligaments that are attached to the skeleton. These receptors respond to the deformation of their surrounding tissues by mechanical forces arising from the muscles, the environment or both. Carello and Turvey (2004) define the muscle sense as one of the several subsystems making up the haptic perceptual system, which is responsible for proprioception.

Proprioception, which is defined as a sixth sense developed by the nervous system, refers to the gathering of internal sensory information that gives us information about the joint position, muscle tension and the location of the body part in space (Gooey et al., 2000; Schmidt and Wrisberg, 2004).

There are three principle types of receptors: cutaneous, muscle and joint mechanoreceptors. These receptors are responsible for providing neuromuscular system with information about joint position and movement sense (Lee et al., 2003; Lephart et al., 1997; Powers and Howley, 1997; Schmidt and Wrisberg, 2004). They are located under the skin, muscles and joint and surrounding joint capsules as well as ligaments and tendons (Lephart et al., 1997; Schmidt and Wrisberg, 2004). Cutenous receptors, found under the skin, are responsible for providing haptic information, i.e. feeling. The receptors found in the muscle, muscle spindles (Table I), are responsible for giving information about the rate of contraction as well as changing the position of the joints (Schmidt and Wrisberg, 2004). Another muscle mechanoreceptor is Golgi tendon organs (Table I). They are located at the junction of muscles and tendons and provide signals about the force in muscles (Lephart et al, 1997; Schmidt and Wrisberg, 2004). Joint mechanoreceptors, which are Ruffini endings, Pacinian Corpuscles and unmyelinated free nerve endings (Table II), have been shown in the capsule and ligaments of all joints (Newton, 1982; Lephart et al., 1997; Warner et al., 1996). These mechanoreceptors are stimulated strongly at the beginning of the movement and transmit information about joint position and motion. Because of stimulation, muscles contract and adapt rapidly to sudden movements of acceleration or deceleration. These mechanoreceptors are also responsible for extreme range of motion (Powers and Howley, 1997; Warner et al., 1996).

Table1. Muscular Mechanoreceptors (Lephart et al., 1997)

Receptor Type	Location	Adaptation Rate	Function
III, Golgi tendon organ	Tendons	Slow	Reflex
Muscle spindle	Muscle	Slow	Reflex (stretch reflex)

Table2. Articular Mechanoreceptors and Articular Noiceptors (Lephart et al., 1997)

Receptor Type	Location	Adaptation Rate	Function
I, Ruffini endings	Joint capsule and ligaments	Slow	Joint pressure
II, Pacinian Corpuscule	Joint capsule	Quick	High frequency vibration
IV, Unmyelinated free nerve endings	Ligaments	Slow	Joint pain

These receptors work together to provide the body orientation as well as feedback relative to the rates of limb movement (Powers and Howley, 1997). Proprioception is necessary for optimum joint function in sports, occupational tasks and daily living activities (Safran et al, 2001). Furthermore, proprioception is also involved in the learning of new movements (Cordo et al, 1994).

Placement of the hand for upper limb function is partially dependent on the perception of joint position and joint motion of the shoulder (Warner et al., 1996). The functional stability of the shoulder joint, which includes several bone and joint structures, is maintained through the collaborative effect of ligaments and the rotator cuff muscular complex, as well as other muscles (Pedersen et al, 1998). Rotator cuff muscles (Table 3) constitute one of the sources of proprioceptive signals, which play primary role in timing and optimal muscular control in the shoulder joint (Carpenter et al., 1998; Janwantanakul et al., 2003; Kablan et al., 2004; Warner et al., 1996).

Table 3. Rotator cuff muscles (Shier et al., 1996)

Muscle	Function
Supraspinatus	Abducts the arm
Subscapularis	Rotates arm medially
Infraspinatus	Rotates arm leterally
Teres minor	Rotates arm leterally

In addition, according to Lee and co-workers (2003), a coordinated and synergistic contraction of rotator cuff and biceps muscles may prevent the ligaments from injury. Proprioceptive deficit (figure 2) may lead to failure of rotator cuff muscles in preventing excessive movement of the shoulder complex. This leads to a disrupt coordinated movement at other joints along the kinetic chain by altering the motor program and, thus, causes a decrease in performance (Kablan et al., 2004; Myers and Lephart, 2002).

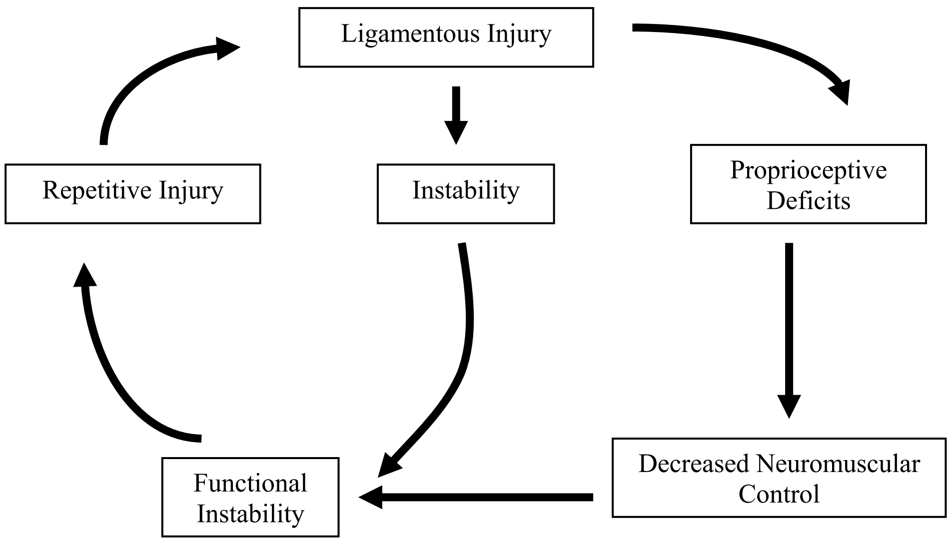


Figure 1. Functional stability paradigm showing the progression of functional instability of the glenohumeral joint because of the interaction between mechanical instability and decreased neuromuscular control (Lephart et al., 1997).

In the literature, there is a lack of evidence regarding the effect of different body positions on shoulder proprioceptive sense of tennis players. Shoulder proprioceptive sense was measured while the participants were sitting and lying in supine positions in previous studies (Alvemalm et al., 1996; Janwantanakul et al., 2003). However, tennis activities such as service, forehand, and backhand hits are performed in standing. Therefore, this study aims investigating the shoulder proprioception in sitting and standing positions. It has two principle aims.

The initial purpose of this study was to assess shoulder proprioceptive differences between tennis players and age matched sedentary controls. The second purpose was to evaluate shoulder proprioception between dominant and non-dominant shoulders. Measurements were made at 15º internal and external shoulder rotation and at 30º neutral internal and external shoulder rotation in sitting and standing positions to stimulate service, forehand and backhand motions of tennis. Standing measurement positions were defined and used along the experiments.

1.1 Limitations

1. Tennis players who participated in this study were all male. Female players were not involved and gender differences were not assessed in this study.
2. The players were from three different tennis clubs.
3. A small sample size was measured due to the lack of availability of players at ages 14-16.
4. Effect of fatigue was not determined.

1.2 Assumptions

1. Participants presented their best performance during tests.
2. The subjects were not rotating their trunk during the standing test position.
3. Sedentary controls did not participate in any other sporting activity except their weekly physical education and sport classes at school.

1.3 Hypotheses

1. There will be significant differences between players and control subjects in terms of shoulder proprioceptive sense in 15º and 30º external and internal rotation.
2. There will be no significant differences between sitting and standing forehand and backhand positions in terms of shoulder proprioceptive sense in both groups.
3. There will be no significant proprioceptive differences between the dominant and non-dominant shoulders at all positions.

1.4. SIGNIFICANCE OF THE STUDY

In daily living activities and sports, optimum joint function heavily depends on normal proprioceptive sense. The deficiency in proprioception may lead to joint instability and results in decrease of performance. The importance of any finding during this study may lead to an overall training that would help the physically active to improve proprioceptive sense. This study is investigating shoulder proprioception in service, forehand, and backhand positions in tennis players and age matched sedentary controls. The present study is additionally evaluating the gleno-humeral joint position sense in different body positions ‘sitting’ versus ‘standing’. Furthermore, it is measuring the difference in proprioceptive sense between dominant and non-dominant shoulders.

1.5. DESCRIPTIONS OF THE TERMS

Acyclic sports: These exercises are composed of integral functions performed in one action.

Backhand: Ground stroke hit on the left side for a right handed player and on the right side for a left handed player.

Baseline: The chalk line at the farthest ends of the court indicating the boundary of the area of play.

Coronal Plane: From the nose to the back of the head

Extension: Movement of the joint which increases the angle between its articulating segments.

Flexion: Movement of the joint which decreases the angle between articulating segments.

Forehand: Ground stroke hit on the right side of a right handed player or on the left side of a left handed player.

Haptic perception: Involves both tactile perception through the skin and kinaesthetic perception of the position and movement of the joints and muscles. For example, if we hold a cube, we perceive it through the skin of our fingers and the position of our fingers.

Proprioception: sensitivity mechanism in the body that sends messages through the central nervous system. The central nervous system then relays information to rest of the body about how to react and with what amount of tension.

Rotation: Movement of a joint about the longitudinal axis in the transverse plane.

Rotator Cuff Muscles: Rotator muscles of the shoulder joint. They consist of the supraspinatus, the infraspinatus, and the teres minor that rotate the shoulder externally and the subscapularis one of the muscles which rotates the shoulder internally.

Scapular Plane: This model allows for the position of the bones of the shoulder to be observed in relation to the underlying rib cage. Due to its positioning on the rib cage, the scapula is offset 30 degrees from the frontal plane this is called the scapular plane.

Serve: The shot used to put the ball into play - the ball is tossed in the air, and then hit with one hand to go over the net.

CHAPTER II

REVIEW OF LITERATURE

2.1 INTRODUCTION

In tennis, according to Crespo and Miley (1998) an optimum technique, which enhances control, and power, delays fatigue and prevents injury, depends on using the body parts effectively. These body segments consist of legs, hips, trunk, shoulder, elbow, and wrist. In addition, they stated that missing one of these parts decreases the power and control and increases the risk of injury.

In tennis extreme stress is placed on the shoulder joint due to numerous movements (Brown et al., 1988; Chandler et al., 1992). During the repetitive strokes, high forces are generated around glenohumeral complex. Improper technique and inadequate muscular endurance may lead to overuse injury in the shoulder joint in tennis players (Ellenbecker and Roetert, 2003; Ryu et al., 1988). In Priest and Nagel's (1976) survey, proffesional tennis players experienced shoulder injuries at some time through their careers. Kibler et al. (1989) reported that, among junior tennis players, the most injured part of the body is the shoulder joint.

Warner et al. (1996) declared that, movement of the hand is necessary during daily and sport-specific (Lephart et al. 1997) activities and depends on the perception of joint position and joint motion of the glenohumeral complex. The term of proprioception refers to the sensory modality which provides information about position and movement. This sensory mechanism is mediated by receptors found in muscles, joints and skin. Repetitive movements may damage the capsuloligamentous structures and result in instability of the shoulder joint (Lephart et al. 1994). Alvemalm et al. (1996) stated that deficiency or injury of any of these structures may affect the proprioceptive sense negatively. Myers and Lephart (2002) supported these ideas; according to them, glenohumeral joint instability resulted in proprioceptive deficit and alterations in the neuromuscular mechanisms.

On the other hand, proprioceptive sense is necessary for neuromuscular control in order to perform the movements precisely, and provide the stability of joints (Lephart et al. 1997). Safran et al. (2001) decleraded that, proper joint function in sports, and in activities of daily living depends on concious proprioception.

The further review of the literature encompasses the demand of tennis sport, shoulder mechanism in tennis, role of proprioception, shoulder proprioception, and shoulder proprioception in sports:

2.2 DEMANDS OF TENNIS SPORT

Bergeron et al. (1991) demonstrated that, in tennis sport the overall metabolic response resembles prolonged moderate-intensity exercise. In a review, König and co-workers (2001) stated that in a tennis match the overall intensity ranges between 60-70 % of maximum oxygen uptake, and aerobic energy metabolism mainly provide for the energy requirements. They also claimed that, during frequent periods of high intensity, muscular energy is provided by anaerobic glycolisis metabolism.

Bernardi et al. (1998) in their study classified the players into three groups; baseline players, attacking players and whole-court players. They found that, the mean duration of the rally was related to the type of play in the match, the longer duration of the rally, the higher the intensity of the exercise.

Smekal et al. (2001) examined the physiological demands of single match play in tennis. 20 players performed 10 matches of 50 min. Respiratory gas exchange measures (RGEM), and heart rates (HR) were measured using two portable systems. They found that, in games of two defensive players, VO_2 was significantly higer than in games with at least one offensive player. They concluded that, energy demands of tennis matches were significantly influenced by duration of rallies.

The effect of recovery duration in intermittent training drills on metabolism and coordination in sport games was assesed by Ferrauti et al. (2001).

They demonstrated that, running speed and stroke quality during intermittent tennis drills were highly dependent on the duration of recovery time.

According to Chandler (1998), sport of tennis requires repeated bouts of moderate to high-intensity exercise. Assessment of the muscle strength, muscle balance, and joint range of motion (ROM) of an individual player provides crucial information about his/her strengths and weaknesses. Work-rest intervals during high levels of tennis play are compromised of an approximate 1:2 work-rest interval, with the duration of the points averaging 8-10 s on a hard surface.

2.3 SHOULDER MECHANISM IN TENNIS

College tennis players were tested for billateral shoulder internal/external rotation strenght. Subjects produced significantly more power and torque in internal rotation in the dominant arm when comparing with the nondominant arm. In terms of external rotation there was no significant difference between the dominant shoulder and nondominant shoulder (Chandler et al., 1992).

Chandler and co-workers (1990) measured the flexibility of junior tennis players and athletes involved in other sports. They found that, tennis players scored significantly lower in the flexibility test, dominant shoulder internal rotation, and nondominant shoulder internal rotation. However, they were more flexible in dominant and nondominant shoulder external rotation.

It has been investigated that, muscles, which are subscapularis, serratus aterior, supraspinatus, infraspinatus, pectoralis major, middle deltoid, and biceps brachii, display greatest activity during the serve, forehand, and backhand strokes (Ryu et al., 1988).

In a study, Mont et al. (1994) used isokinetic concentric and isokinetic eccentric training models for two different groups of elite tennis players respectively. It was found that both of the training regiments proved strength gains in elite tennis players in comparison to the control group. It was concluded that isokinetic training led to increase in objective and functional outputs in elite tennis players.

In order to examine the effect of isotonic resistance training, elite level collage tennis players were examined in experimental and control groups (Treiber et al., 1998). They showed that, the subjects who performed isotonic resistance training had better internal and external rotation torque when compared with the control group.

According to Ellenbecker and Roetert (2003), in elite junior tennis players dominant arm internal rotation is significantly greater than dominant arm external rotation.

Isokinetic testing for internal and external shoulder rotation and upper extremity range of motion measurements were performed with baseball players. The internal shoulder rotators were found to be significantly stronger than the external rotators (Brown et al., 1988).

Kibler et al. (1996), studied the glenohumeral rotational range of motion in professional tennis players. The measurements of internal and external rotation of dominant and nondominant arms were made by goniometri. They categorized the players according to their age and years of experience in tournaments. This study demonstrated statistically a significant loss in shoulder internal rotation in tennis players. Age and years of tournament play affected this loss progressively.

Terminal range eccentric antagonist/concentric agonist rotator cuff strenght in overhead athletes was measured by Yıldız et al. (2005). In that study, the dominant and non-dominant shoulders of 40 asymptomatic military overhead athletes were tested through a range of 20^0 of external rotation to 90^0 of internal rotation using the speed of dynamometer at 90^0 /s. The muscle torque ratios of eccentric antagonist / concentric agonist were different between dominant and non-dominant shoulders of skilled overhead athletes at terminal ranges.

Specific test for flexibility, strength, and endurance were examined by Kibler et al. (1989). Two thousand and one hundred seven athletes from different sports from junior high to the college level, participated in this study. Muscular strength and endurance tests were sit-ups, push-ups, grip strength, a knee Cybex test on lower body athletes, and a shoulder Cybex test on upper body athletes. Flexibility test included standard gonimetric range of motion measurements of maximal shoulder, hamstring, quadriceps, gastrocnemius, and lower back flexibility. One of the main findings of this study was that upper-body athletes were tighter in dominant side internal rotation and significantly looser in dominant side external rotation.

2.4 ROLE OF PROPRIOCEPTION

Awareness of posture, movement, and knowledge of body position, weight, and changes in equilibrium and resistance of objects in relation to the body is a definition of proprioception. These information arrive at the brain from different sources including the muscle spindle, joint capsule and ligaments, and skin (Gurney et al., 2000).

In a rewiev Lephart and Jari (2002) declared that, stability of the glenohumeral joint is provided by different mechanisms such as articular geometry, muscular stabilizers, static capsuloligamentous tissues, and intra-articular tissues. These structures may help to the stability of the joint by providing affarent feedback for muscular contraction of rotator cuff and biceps brachii. By means of which proprioceptors muscles receive feedback in order to work properly. They also stated that, proprioception has a crucial role for normal function of the shoulder muscles and in protecting the shoulder against potential instability.

Role of velocity and position sense on proprioceptive coordination of movement sequences were analyzed by Cordo et al. (1994). The measurement was held with 23 subjects without neuromuscular deficit. The apparatus passively rotated the right elbow horizontally in the extension direction with either a constant velocity trajectory or unpredictible velocity trajectory. The researchers claimed that the central nervous system extracts and uses proprioceptive information related to both velocity and the angular position of the joint (Cordo et al., 1994).

In an another review, Myers and Lephart (2002) discussed the sensorimotor role that the capsuloligamentous structures play in providing stability; how these mechanisms are disrupted with glenohumeral instability and how surgical interventions restores such mechanisms. They stated that, the information of proprioception transmitted from the capsuloligamentous structures, including mechanoreceptors, influenced coordination of the motor program, and reflex activity to provide glenohumeral joint stability. The injury in capsuloligamentous structures that occurs with shoulder instability not only affects mechanical restraint, but also changes the proprioceptive input to the central nervous system. Reflex activity and motor programs are altered because of the deficiency of proprioception.

Lephart and co-workers (1997) in a review, investigated the role of proprioception in the management and rehabilitation of athletic injuries. It was stated that, skin, articular, and muscle mechanoreceptors responsible for mediating the affarent feedback to the brain and spinal pathways. Examining the effects of injury in ligaments, surgical intervention, and propioception in the rehabilitation program provides an understanding of the complexity of this system responsible for motor control. Injury and abnormalities interrupt this neuromuscular feedback mechanisims. Surgical intervention and rehabilitation programs are implemented to restore this feedback mechanisim. They also recommended that to promote dynamic joint and functional stability, rehabilitation program should include motor control levels; spinal reflexes, cognitive programming, and brainstem activity.

Blasier et al. (1994) measured 29 subjects with normal shoulder in order to investigate the effect of joint laxity, position, and direction of motion. The authors deliberately included some subjects with joint laxity in the study group and found that subjects clinically determined generalized joint laxity were significantly less sensitive in proprioception. Detection of internal rotation was less than that of external rotation.

In another research Alvemalm et al. (1996) measured the ability of 30 subjects (15 normal and 15 patient) to reproduce a shoulder joint angle with a Kincom passive and active test. The results demonstrated that, the mean error of reproducing the target angle was lower in the normal group in comparison with the patient group.

Warner et al. (1996) assessed proprioception in subjects with normal shoulders, unstable shoulders, and after surgical stabilization, by evaluating the detection of passive motion and the ability to passively reposition the arm in space. The shoulder was positioned at 90^0 abduction in the plane of the body with the elbow at 90^0, and all external stimuli were eliminated. Proprioception testing device allowed the shoulder to move at a constant angular velocity of $0,5^0$ per second with random movement into either internal or external rotation. The outcome of the study stated that, in normal shoulders there was no difference between the dominant and nondominant shoulder, though in unstable shoulders there was a significantly decreased proprioceptive ability.

Beard et al. (1994) investigated the efficacy of two rehabilitation programs on 50 subjects with anterior cruciate ligament deficiency in knees. Half of the subjects participated in muscle strengthening program and the others participated in proprioception enhancing program. The main outcome of this study was that the improvement in group 2 was significantly greater than group 1. Paterno and coworkers (2004) examined the hypothesis that neuromuscular training improved single-limb stability in young female athletes. 41 healthy female high school athletes participated in their study. Following the completion of the training program, each subject was re-evaluated to determine change in total, anterior posterior, and medial-lateral single-limb stability. A significant improvement in single-limb total stability and anterior-posterior stability, but not medial-lateral stability for both the right and left lower extremity following training was noticed. The subjects demonstrated significantly better total postural stability on the right side as compared to the left.

2.5 SHOULDER PROPRIOCEPTION

The effect of body orientation, sitting versus lying supine, on shoulder proprioception was examined by Janwantanakul et al. (2003). Fifteen healthy right-handed males were measured in this test of passive repositioning and threshold for detection of imposed movement to examine position and movement sense acuity. It was found that body orientation influenced shoulder proprioception.

Alterations in the movement sense acuity during localized muscle fatigue in human dominant shoulder were investigated by Pedersen et al. (1998) with 14 healthy subjects. This test consisted of 2 parts; ligth exercise, repetitive horizontal flexion/ extension at the shoulder ranging from 85º to 20º at 10 % of maximal voluntary contraction, and hard exercise, same as the light exercise but with maximum voluntary contraction. Subjects had a lower probability of distinguishing between different movement velocities following hard exercise as compared with those during the light exercise condition. The acuity of the movement sense in the dominant shoulder was reduced in the presence of shoulder muscle fatigue.

Another study carried out by Lee et al. (2003) investigated the effect of shoulder muscle fatigue on glenohumeral proprioception by measuring 11 subject with normal shoulders. The test composed of active and passive reproduced test and they found no significant difference on shoulder proprioception between pre and post fatigue determinations of passive repositioning in shoulder internal rotation, external rotation and active repositioning in external rotation. Active repositioning in external rotation was mainly affected by muscle mechanoreceptors in the presence of muscle fatigue.

Kablan et al. (2004) investigated the factors affecting the shoulder proprioceptive sense among male volleyball players. Twenty elite, and 20 beginner volleyball players participated in this study. Shoulder proprioception sense was determined by measuring participant's perception of joint position with the joint at 90º abduction, external rotation and 90º abduction, natural rotation.

The proprioception test was performed before and after fatigued exercise with dominant extremities. No significant difference was found between elite and beginners in the proprioception scores at 3 angles in both directions before and after the fatigue test.

Aydın et al. (2001) investigate the proprioception of the joint in healthy and surgically repaired shoulders with 44 subjects who were assigned to two experimental groups: group 1, healthy subjects, and group 2, patients who have undergone surgial reconstruction. In group 1 there was no significant difference between the dominant and nondominant glenohumeral joint proprioception. There were not significant mean differences between the surgical and contralateral shoulder in group 2 under any test condition.

The effect of open and closed kinetic chain exercise on shoulder position sense was investigated by Rogol et al. (1998). The subjects were divided into three groups; open kinetic exercise, closed kinetic exercise, and a control group. Subjects participate in 6-week training program with 3 session per week. They found that open and closed kinetic chain groups decreased error score of the reposition sense compared with control group, but no different between exercise groups.

2.6 SHOULDER PROPRIOCEPTION IN SPORTS

Glousmann and coworkers (1988) observed the changes in the electromyographic pattern in baseball pitchers demonstrating shoulder instability.

Reduction in neuromuscular activation of the pectoralis major, subscapularis, and latissimus dorsi muscles was found to contribute to anterior instability through a decrease in the normal internal rotation force required for this motion. Biceps and supraspinatus muscles observed in an attemp to restore anterior stability. This loss in the neuromuscular mechanisim in the unstable shoulder has been attributed to changed joint function resulting in repetitive microtrauma.

To assess if the hypothesis that female softball athletes have decreased joint position sense in their dominant shoulder as compared with their nondominant shoulder Dover et al. (2003) measured 50 female softball players and 50 non-throwing female athletes by using an inclinometer during 4 glenohumeral joint motions. Both dominant and nondominant shoulders were assessed and error scores were calculated to describe joint position sense. Softball athletes demonstrated significantly greater external rotation error scores than the nonthrowing athletes. Increased error scores (less JPS) were observed in both arms of the subjects in the softball group.

Safran et al. (2001) examined proprioceptive differences between the dominant and nondominant shoulders of 21 collegiate baseball pitchers without a history of shoulder instability of surgery. The shoulder was tested from 3 starting positions into internal and external rotation. They found that joint position sense was significantly more accurate in the nondominant shoulder than in the dominant shoulder when starting 75% of maximal external rotation and moving into internal rotation. There were no significant differences for proprioception in the other measured positions. There was no difference in joint position sense between dominant and nondominant shoulders of high-level baseball pitchers.

Jerosch et al. (1997), evaluated the proprioception capability of adolescent tennis players. Forty were tennis players participated in the study and, 20 non tennis players participated as the control group. Angle reproduction of all volunteers was best in the midrange of motion (100º flexion, 100º abduction, neutral rotation in 90º abduction). The worst results were documented below shoulder level (50º flexion, 50º abduction, internal rotation in 90º). A correlation to sex or dominant extemity could not be found. Subjects older than 12 years showed a tendency for better angle reproduction compared to the younger subjects. Tennis players older than 12 years demonstrated significantly better capabilities for angle reproduction in some movements of the shoulder complex.

Swanik et al. (2002) investigated the effect of plyometric training of the shoulder internal rotators on proprioception, kinesthesia, and selected muscle performance characteristics in 24 female swimmers before and after a 6-week plyometric training program. They found that proprioception and kinesthesia demostrated significant improvements after plyometric training.

CHAPTER III

METHODS AND PROCEDURES

3.1 Participants

The participants of this study were 15 trained male tennis players from three different sports clubs (Devlet Su İşleri, ODTU, and Ankara Tennis clubs). 15 age matched sedentary males established the controls. The participants were healthy and free of any upper extremity injury. All participants participated in this study voluntarily. Permission was obtained from their families. All participants were provided with a written consent on the possible risks and benefits of the experimental procedure. A personal information sheet was distributed to gather their experience in this sport.

3.2 Data Collection

At the beginning of the study, relevant clubs' coaches were contacted to inform them on the purpose of the study. They were also asked for the availability of their training program for measurements and to motivate their players to participate in this study. Having the permission from their coaches, all subjects were informed on the inventory, which was used during data collection.

3.3 Research Design

In this cross-sectional study, participants were selected according to their availability for tests. In order to insure a high degree of internal validity, following steps were implemented. All tests were standardized. To eliminate contaminating neuromuscular response, the subjects were asked not to participate in any strenuous exercise 24 hour prior testing. All testing were performed approximately at the same time of the day.

Measurements were made at sitting and standing positions.

3.3.1 Variables

This current study included eleven variables. One of them was independent variable and ten of them were dependent variables. Group was independent variable in this study. Dependent variables were: Dominant shoulder service position, Non-dominant shoulder service position, Dominant shoulder sitting forehand position, Non-dominant shoulder sitting forehand position, Dominant shoulder sitting backhand position, Non-dominant shoulder sitting backhand position, Dominant shoulder standing forehand position, Non-dominant shoulder standing forehand position, Dominant shoulder standing backhand position, Non-dominant shoulder standing backhand position.

3.3.2 General Procedures

Anthropometric Measurements: Anthropometric parameters of participants in t-shirts, shorts and socks were measured before the test.

Body height was measured by a Seca anthropometer, and body weight in kgs by a Seca beam-balance scale in laboratory conditions. BMI was calculated by the formula kg / m^2.

3.3.3 Proprioception Tests

Shoulder proprioception was evaluated by Biodex isokinetic system 3 pro (Biodex Medical Systems, Inc., New York, USA). The system has isokinetic, isometric, isotonic, passive, reactive eccentric exercise modes and also proprioception measurement protocols. The reliability and validity of the Biodex system has been demonstrated in previous studies (Aydin et al., 2001, Janwantanakul et al., 2001, Kablan et al., 2004, Safran et al., 2001).

Shoulder proprioception was determined by measuring the subject's joint position perception (Aydın et al., 2001; Safran et al., 2001; Janwantanakul et al., 2001). Participants were tested in a seated and standing position and they were blindfolded and headsets placed over the ears to eliminate external visual and auditory stimulants (Aydın et al., 2001; Lee et al., 2003). Service motion, sitting forehand - backhand motions, and standing forehand - backhand motions' (Table

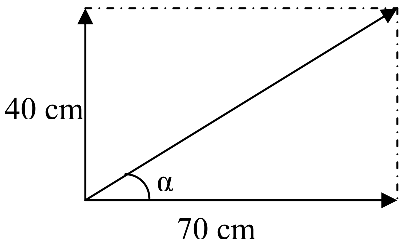
4) proprioception test lasted about one hour and thirty minutes. The participants were brought to the laboratory in groups of two in order to prevent boredom, and increase motivation.

Table4. Kinds and Degrees of Measurements

Kinds of Measurement	Degrees of Internal and External Rotation
Sitting Service	15º
Sitting Forehand	30º
Sitting Backhand	30º
Standing Forehand	30º
Standing Backhand	30º

The perception of joint position for service motion was assessed by measuring reproduction of passive positioning at 15º joint angle in direction of internal and external rotation, as conducted by (Aydın et al., 2001; Safran et al., 2001; Kablan et al., 2004).

The joint perception of forehand and backhand motions were assessed as follows; Impact area of a racket and a ball should be in the front and at a comfortable distance from the body (Lateral=70 cm, Forward=40 cm) (Elliot et al., 2003). The angle between lateral base position and forward base position was approximately 30º.



$\tan\alpha = 40/70$

$\arctan(\tan\alpha) = \arctan(40/70)$

$\alpha = \arctan(40/70)$

$\alpha \approx 30^{o}$

The joint angle measured in forehand and backhand at 30º in directions of internal and external rotations.

The speed of all measurements was made at 5 deg/s (Gurney et al., 2000; Janwantanakul et al., 2003). This speed was thought to be sufficient to minimize the effect of a subject's response time on the test outcome (Janwantanakul et al. 2003).

The shoulder joint was tested from the starting position. When participants were ready, the limb was moved passively to first angle of internal rotation at a rate of 30 deg/s. The shoulder was positioned in the presented angle for 10 seconds and the subjects were asked to concentrate on this position. The limb was then moved passively by the device either externally or internally at a constant speed of 5 deg/s. Then, the participants were asked to reproduce joint angles that were previously presented. The subjects manipulated the handheld on/off switch when they thought their joint had reached the previously presented position.

a) For the serve motion, the shoulder joint was positioned at 90º abduction and 90º external rotation and internal rotation and the elbow flexed to 90º. The dynamometer rotated the shoulder into reference angle which was 15º of internal rotation.

Figure 3. Shoulder proprioception test at 15º

The elbow was extended at approximately at 150º by attaching a splint. This provided stabilization and immobilization of the limb proximal to the elbow in flexion and distal to the elbow in external rotation.

b) For the sitting forehand motion, the shoulder joint was positioned at 30º abduction and 90º internal and external rotation and the elbow extended approximately 150º, and the chair was rotated at 30º, dynamometer was rotated at 30º, and dynamometer tilt was 70º from vertical base position. The dynamometer rotated the shoulder into reference angle which was 30º of internal rotation.

(a) Starting Position (b) Final Position

Figure 4. Shoulder roprioception in sitting forehand test; (a) starting position, (b) final position

c) For the sitting backhand, the shoulder joint was positioned at 30º abduction and 70º external and internal rotation and the elbow was extended approximately at 150º, and the chair was rotated at 30º, dynamometer was rotated at 30º, and dynamometer tilt was rotated at 30º from horizontal base position. The dynamometer rotated the shoulder into reference angle which was 30º of external rotation.

Figure 5. Shoulder roprioception in sitting backhand test; (a) starting position, (b) final position

d) For the standing forehand, the shoulder joint was positioned at 30º abduction and 90º internal and external rotation and the elbow extended approximately at 150º, dynamometer was rotated 90º , dynamometer tilt was rotated at 30º from horizontal base position, the feet were placed as open stance. The dynamometer rotated the shoulder into 30º of internal rotation.

(a) Starting Position (b) Final Position

Figure 6. Shoulder proprioception in standing forehand test; (a) starting position, (b) final position

e) For the standing backhand, the shoulder joint was positioned at 30º abduction and 70º external and internal rotation and the elbow extended approximately at 150º, and dynamometer was rotated at 90º, and dynamometer tilt was adjusted at 30º from horizontal base position, the feet were placed as semi-square stance. The dynamometer rotated the shoulder into 30º of external rotation.

(a) Starting Position (b) Final Position

Figure 7. Shoulder roprioception in standing backhand test; (a) starting position, (b) final position

3.4 Statistical Analyses

The SPSS for Windows (11.5) software was used for statistical analysis. Shoulder proprioceptive differences between players and control groups were investigated by MANOVA. It was determined that dominant shoulder service position at 15º, non-dominant shoulder service position at 15º, dominant shoulder sitting forehand position at 30º, non-dominant shoulder sitting forehand position at 30º, dominant shoulder sitting backhand position at 30º, non-dominant shoulder sitting backhand position at 30º, dominant shoulder standing forehand position at 30º, non-dominant shoulder standing forehand, dominant shoulder standing backhand position at 30º, and non-dominant shoulder standing backhand position at 30º are dependent variables. Group is independent variable of the study. Paired t-test was used to evaluate the differences between dominant and non-dominant shoulders and the differences between sitting and standing positions. The level of statistical significance was $p < 0.05$.

CHAPTER IV

RESULTS

4.1. Subjects Characteristics

In this study 15 young tennis players and 15 young non-players participated on a voluntary basis, who were not on a special diet and were not using any medication that could interfere with their health conditions. Mean age, height, weight, BMI, and playing experience of the participants are presented in Table 4.1.1.

Table: 4.1.1. Physical Characteristics of the Subjects.

Group	Age (year)	Height (m)	Weight (kg)	BMI (kg/m^2)	Playing Experience (year)
Tennis Players	14.6 ± 0.7	1.69 ± 0.06	63.9 ± 5.5	22.2 ± 1.0	7.3 ± 1.7
Non-players	14.8 ± 0.9	1.68 ± 0.05	64.4 ± 10.2	23.1 ± 3.9	

There was a significant difference between tennis players and nonplayers in terms of shoulder proprioceptive sense in 15º and 30º external and internal rotation (Table 4.2.1). In addition, there was a significant difference intra-group members in terms of non-dominant sitting forehand and non-dominant standing backhand positions at 30º external and internal rotations. However, proprioceptive sense intra-group members remained similar at 15º and 30º in both direction in all other parameters (Table 4.2.2).

Table 4.2.1. Multivariate Analysis of Variance Test Result#

Effect	Value	F	Hypothesis df	Error df	Sig.	Eta Sq.	Observed Power[a]
Group	.558	2.401	10	19	.048	.558	.380
	.442	2.401	10	19	.048	.558	.380
	1.264	2.401	10	19	.048	.558	.380
	1.264	2.401	10	19	.048	.558	.380

All values in the MANOVA above were given according to Pillai's Trace, Wilks' Lambda, Hotelling's Trace, Roy's Largest Root.

[a] Computed using alpha = .05

Table 4.2.2. Test of Between Subjects Effects

Source	Dependent Variable	F	Df	Sig.	Observed Power[a]
Group	Dominant @ Service	.128	1	.723	.008
	Non-dominant @ Service	.759	1	.391	.023
	Dominant forehand @ Sitting	.336	1	.567	.012
	Non-dominant forehand @ Sitting	5.671	1	.024	.277
	Dominant backhand @ Sitting	.344	1	.562	.012
	Non-dominant backhand @ Sitting	.327	1	.572	.012
	Dominant forehand @ Standing	2.687	1	.112	.100
	Non-dominant forehand @ Standing	2.797	1	.106	.106
	Dominant backhand @ Standing	1.734	1	.199	.057
	Non-dominant backhand @ Standing	4.809	1	.037	.222

[a] Computed using alpha = .05

4.3. The Results of Comparison of Seated Positions and Standing Positions in Proprioceptive sense at Thirty Degree.

Findings indicated that there was no significant difference in shoulder proprioception at seated and standing positions in tennis players. In addition, except one parameter, the same results were observed in control group.

The paired t-test for tennis players revealed that there was not a significant difference between dominant shoulder sitting forehand and dominant shoulder standing forehand positions, non-dominant shoulder sitting forehand and non-dominant shoulder standing forehand positions, dominant shoulder sitting backhand and dominant shoulder standing backhand positions, and non-dominant shoulder sitting backhand and non-dominant shoulder standing backhand positions (Table 4.3.1).

The paired t-test for control group indicated that there was not a significant difference between dominant shoulder sitting forehand and dominant shoulder standing forehand positions, dominant shoulder sitting backhand and dominant shoulder standing backhand positions, and non-dominant shoulder sitting backhand and non-dominant shoulder standing backhand positions. However, there was statistically significant difference between non-dominant shoulder sitting forehand and non-dominant shoulder standing forehand positions (Table 4.3.2)

Table 4.3.1. Comparison of Dominant Shoulder Sitting Forehand and Backhand Positions and Dominant Shoulder Standing Forehand and Backhand Positions at Thirty Degree in Tennis Players.

Test	N	Mean ± sd	Df	t-value	Sig.2-tailed
Dominant forehand @ sitting & Dominant forehand @ standing	15	34 ± 9 38.5 ± 5.5	14	-1.734	.105
Non-dominant forehand @ sitting & Non-dominant forehand @ standing	15	33.5 ± 5.5 38 ± 8	14	-2.075	.057
Dominant backhand @ sitting & Dominant backhand @ standing	15	29 ± 5 33 ± 7	14	-1.639	.124
Non-dominant backhand @ sitting & Non-dominant backhand @ standing	15	31 ± 5 33 ± 8	14	-1.030	.321

Table 4.3.2. Comparison of Dominant Shoulder Sitting Forehand and Backhand Positions and Dominant Shoulder Standing Forehand and Backhand Positions at Thirty Degree in Sedentary Controls.

Test	N	Mean ± sd	Df	t-value	Sig.2-tailed
Dominant forehand @ sitting & Dominant forehand @ standing	15	36 ± 9 35 ± 7	14	.422	.679
Non-dominant forehand @ sitting & Non-dominant forehand @ standing	15	38.5 ± 5.5 33 ± 8	14	2.384	.032
Dominant backhand @ sitting & Dominant backhand @ standing	15	30 ± 3 30 ± 7	14	.103	.920
Non-dominant backhand @ sitting & Non-dominant backhand @ standing	15	29 ± 8 28 ± 4	14	.598	.559

4.4. The Results of Comparison of Proprioception Between Dominant Shoulder and Non-dominant Shoulder at Two Angles.

According to the results of paired t-test there was not a significant difference in proprioceptive sense between dominant shoulder and non-dominant shoulder of the tennis players at 15º and 30º (Table 4.4.1). In addition, noticeable difference in proprioception was not observed between dominant and non-dominant shoulders at 30º in control group. However, statistically significant difference was observed in dominant shoulder service and non-dominant shoulder service proprioceptive sense in control group (Table 4.4.2).

Table 4.4.1. Comparison of Dominant Shoulder and Non-dominant Shoulder in Service, Forehand and Backhand Positions in Tennis Players.

Test	N	Mean ± sd	Df	t-value	Sig.2-tailed
Dominant @ service & Non-dominant @ service	15	24 ± 6 25 ± 10	14	-.416	.684
Dominant forehand @ sitting & Non-dominant forehand @ sitting	15	34 ± 9 33.5 ± 5.5	14	.140	.891
Dominant backhand @ sitting & Non-dominant backhand @ sitting	15	29.5 ± 5.5 31 ± 5	14	-.993	.338
Dominant forehand @ standing & Non-dominant backhand @ standing	15	38.5 ± 5.5 38 ± 8	14	.121	.905
Dominant backhand @ standing & Non-dominant backhand @ standing	15	33 ± 7 33 ± 8	14	.258	.800

Table 4.4.2. Comparison of Dominant Shoulder and Non-dominant Shoulder in Service, Forehand and Backhand Positions in Sedentary Controls.

Test	N	Mean ± sd	Df	t-value	Sig.2-tailed
Dominant @ service & Non-dominant @ service	15	25 ± 6 22.5 ± 5.5	14	2.065	.058
Dominant forehand @ sitting & Non-dominant forehand @ sitting	15	36 ± 9 38.5 ± 5.5	14	-1.019	.325
Dominant backhand @ sitting & Non-dominant backhand @ sitting	15	30 ± 3 29 ± 8	14	.453	.657
Dominant forehand @ standing & Non-dominant backhand @ standing	15	35 ± 7 33 ± 8	14	.574	.575
Dominant backhand @ standing & Non-dominant backhand @ standing	15	30 ± 7 28 ± 4	14	.992	.338

CHAPTER V

DISCUSSION

The main purpose of this study was to investigate the difference in shoulder proprioceptive sense between tennis players and non-players in sitting and standing positions. The second aim was to assess the difference between the dominant and non-dominant shoulders at 15º in sitting position, and at 30º in sitting and standing positions. 15 experienced tennis players, and 15 sedentary people participated in the study.

The results of the present study demonstrated that there was a significant difference between tennis players and non-players in terms of shoulder proprioception. In addition, noticeable significant difference was observed in non-dominant sitting forehand position and non-dominant standing backhand position among participants. However, there was no significant difference in shoulder proprioception in all other parameters among participants.

No significant difference was observed between sitting forehand and backhand positions and standing forehand and backhand positions in terms of shoulder proprioceptive sense in tennis players. Except non-dominant sitting forehand and non-dominant standing forehand positions, similar shoulder proprioception results were observed for control group in sitting forehand and backhand positions, and standing forehand and backhand positions.

The difference was not significant between dominant shoulder and non-dominant shoulder in service, sitting forehand, sitting backhand, standing forehand, and standing backhand positions in tennis players and sedentary control groups.

Jerosch et al. (1997) investigated the shoulder proprioception in male and female tennis players aged between 8 – 16 years. They found that, the players older than 12 years showed better capabilities for shoulder proprioceptive sense. On the other hand, the present study is the first to measure the shoulder proprioceptive sense in young tennis players in terms of comparing the sitting and standing in forehand and backhand positions at 30º, and comparing the dominant and non-dominant shoulders of the participants at 15º and 30º. Shoulder proprioception in young tennis players was investigated in both studies. Jerosch et al. (1997) studied with male and female tennis players aged between 8 – 16 years. However, this study compared tennis players with sedentary controls. In the present study, participants were male and aged between 14 – 16 years. This study is also the first to study with male aged between 14 – 16 years. In previous studies, proprioception assessments have been measured most commonly in internal rotation and external rotation (Warner et al., 1996, Carpenter et al., 1998, Rogol et al., 1998, Aydın et al., 2001, Lee et al., 2003, Kablan et al., 2004). In the present study, neutral internal and neutral external rotations were added in order to provide more information about shoulder joint position sense.

Testing of the shoulder proprioception has been shown to be affected by many factors. These factors have been addressed in this study. As previous studies pointed out, shoulder proprioception is affected by shoulder dislocation (Warner et al., 1996; Blasier et al., 1994). Therefore, it was used as a basis for participant exclusion for this study. In order to prevent the effect of fatigue on shoulder proprioception the subjects were asked have a one-day rest prior to testing (Pedersen et al., 1999; Johnston III et al., 1998).

As can be seen from the results, this study was in agreement with the findings of the previous studies. Alvemalm et al. (1996) found that, there was statistically significant difference between the normal and patient groups in measurement of shoulder joint kinesthesia. Furthermore, Dover et al. (2003) found that, there was a significant difference in external rotation gleno-humeral joint position sense in female softball players as compared with their non-throwing counterparts. In addition, Rogol et al., (1998) explored that the exercise group were able to reproduce angles better and had a better awareness of the location of their upper extremity in space in comparison with the control group. The current study indicates that there is a significant difference between tennis players and non-players. However, Aydın et al. (2001) observed that patients who have undergone surgical reconstruction had proprioceptive sense that did not differ significantly from that of healthy subjects. In their study, the participants were not athletes who participated in sports involving the upper extremities. In our study, the subjects were professional tennis players. The possible explanation why there was a difference between the results of these studies is that shoulder proprioceptive sense can be enhanced with training (Rogol et al. (1998). Swanik et al. (2002) supports this idea with the results of their study. They investigated that polymetric training improves proprioception and kinesthesia. They explained the improvement of proprioceptive sense as peripheral and central neural adaptations. These authors theorized that repetitive stimulation of the articular mechanoreceptors may affect peripheral adaptation. In addition, polymetric exercises require muscle activation at preparatory phase in anticipation of catching the ball and involuntary muscle activation for the production of concentric force while throwing the ball. These adaptations may be responsible for conscious awareness of joint position.

Another finding of the current study was that there was not a significant difference between sitting forehand and backhand positions and standing forehand and backhand positions at 30º in shoulder proprioceptive sense in tennis players and control group. However, a significant difference was found between non-dominant sitting forehand position and non-dominant standing forehand position in control group. This difference may be related with positions which were measured. In the sitting position tests participants' chest were stable. However, in standing position tests the body of participants was not stable. Some of the participants moved their trunk during the standing proprioception test. This movement may affect proprioceptors which are responsible for joint reposition.

Alvemalm et al. (1996) investigated the shoulder joint kinesthesia by comparing the Kincom dynamometer with passive and active test results and a standard clinical test. The Kincom tests were performed with the subjects seated on a chair and the strap firmly placed across their chest. For the clinical test, the subjects were positioned in supine lying on a plinth. The authors found that there was a significant difference between Kincom passive test and the clinical test. The explanation of this difference was that this would be due to the position in which the test was performed. In the clinical test, participants lay supine with their upper arm supported by plinth. Cutaneous receptors from upper arm contact with the plinth, which may have provided additional information about joint position. Janwantanakul et al. (2003) found that the performance of the subjects was better when tested in the sitting position compared with supine lying position. They explained the difference between sitting and lying positions. The level of muscle activity may be related to body positions. In sitting position, anti-gravity muscles, responsible for preventing the body from collapsing, contract. The activity of these muscles is not necessary in the lying position. In active muscles, involving upper trapezius, supraspinatus and deltoid, the muscle receptors may improve the proprioception when compared with inactive muscles. Zuckerman et al. (2003) assessed the proprioception in patients with anterior gleno-humeral instability before and after operative management. Flexion and abduction were tested separately with patients in a seated upright position. External rotation was tested with patients in a standing position. However, they did not analyze the difference between sitting and standing positions in the assessment of shoulder proprioception. In our study, measurements were performed with participants sitting and standing positions. It seems more reasonable to compare proprioceptive sense with these positions because players compete while standing.

It is known that mechanoreceptors demonstrate adaptive properties to a particular stimulus (Warner et al., 1996). Muscle and joint mechanoreceptors tend to mediate the sensation of joint position. In this study, passive motion (5 deg/s) was used to stimulate these receptors. The results of this study revealed that the receptors found in the gleno-humeral joint may adapt to angle which was measured in sitting and standing positions.

Another possible explanation for shoulder proprioception in comparing sitting and standing positions is perceptual learning. Gooey et al. (2000) stated that a familiar posture may lead to perceptual learning. They found that proprioceptive sense at the elbow joint was higher when the arm was placed in daily living postures. According to the results of our study, there was no significant difference between sitting and standing positions. Daily living activities are performed in the upright (sitting and standing) position. The test conditions in our study were the same. This may lead to a neural processing in a position of familiar activity.

Jensen et al. (2000) stated that specific kinds of mental demands such as motivation and attention lead to an increase in muscle activity in certain muscles. It can be inferred that motivation and attention can affect the proprioceptive sense in shoulder muscles. Therefore, in our study, the shoulder proprioception in sitting and standing positions may have been affected by the motivation of the participants.

Finally, there was not a significant difference between dominant shoulder and non-dominant shoulder at 15º and 30º in both groups. This finding was in consistency with previous studies (Warner et al., 1996; Aydın et al., 2001). In contrast of the present study, the participants of these two studies were not athletes who involved in sporting activities; thus the effects of training on shoulders cannot be addressed. Safran et al. (2001) also investigated the shoulder proprioception in baseball pitchers. They found that the proprioceptive sense demonstrated similar properties in the dominant and non-dominant shoulders. This observation was attributed to the benefit of training the upper extremity. In the present study, the difference between dominant service position and non-dominant service position was not statistically significant in control group, but it appeared that the proprioception test was better in the non-dominant shoulder than in the dominant shoulder. Dover et al. (2003) found that internal rotation of joint position sense in non-dominant shoulder was better than in dominant shoulder. A potential explanation of this difference in our study may be the fact that the non-dominant shoulder proprioception was better in internal rotation.

Tennis is enhancing overall shoulder proprioception. If there was a difference between dominant and non-dominant shoulders proprioceptive sense, it would be concluded that tennis had a specific effect on shoulder proprioception. However, it does not exist. The only difference was between tennis players and control groups at 15º and 30º in sitting and standing positions. In future studies, if the same results are obtained from knee proprioception of tennis players, it can be concluded that the sport of tennis improved overall proprioceptive sense in players.

CHAPTER VI

CONCLUSIONS

According to the results of the study, it can be concluded that joint position sense is better in tennis players when compared with that in sedentary controls. No difference was observed between dominant shoulders and non-dominant shoulders in tennis players and age matched sedentary controls in proprioceptive sense. Furthermore, except for the non-dominant shoulder sitting forehand position and non-dominant shoulder standing forehand position in control group there was not any significant difference between sitting and standing positions in all measurements in both groups.

REFERENCES

Alvemalm A., Furness A., & Wellington L. (1996). Measurement of shoulder joint kinaesthesia. Manuel therapy, 1, 140-145.

Aydin T., Yildiz Y., Yanmis İ., Yildiz C., & Kalyon T. A. (2001). Shoulder proprioception: a comparison between the shoulder joint in healthy and surgically repaired shoulders. Archives of orthopaedic and trauma surgery, 121, 422-425.

Beard D. J., Dodd C. A. F., Trundle H. R., Hamish A., & Simpson R. W. (1994). Proprioception Enhancement For Anterior Cruciate Ligament Deficiency. Journal of bone and joint surgery, 76-B, 654-659.

Bergeron M. F., Maresh C. M., Kraemer W. J., Abraham A., Conroy B., & Gabaree C. (1991). Tennis: A physiological profile during match play. International journal of sports medicine, 12(5), 474-479.

Bernardi M., De Vito G., Falvo M. E., Marino S., & Montellanico F. (1998). Cardiorespiratory adjustment in middle-level tennis players: are long term cardiovascular adjustment possible? Science and racket sports II, 20-26.

Birber R. B., Levine R., Galippi L., & Tischler H. (1986). The correlation of performance variables in preadolescent tennis players. Journal of sports medicine, 26, 137-139.

Blasier R. B., Carpenter J. E., & Huston L. J. (1994). Shoulder proprioception; effect of joint laxity, position, and direction of motion. Orthopaedic review, 23, 45-50.

Bollettieri N. (2001). Bollettieri's tennis handbook. Human kinetics, USA.

Bompa O. T. (1999). Theory and methodology of training. Human kinetics, USA.

Brown L. P., Niehues S. L., Harrah A., Yavorsky P., & Hirshman H. P. (1988). Upper extremity range of motion and isokinetic strength of the internal and external shoulder rotators in major league baseball players. The American journal of sports medicine, 16(6), 577-585.

Carello C., & Turvey M. T. (2004). Physics and psychology of the muscle sense. Current directions in psychological science, 13(1), 25-28.

Carpenter J. E., Blaiser R. B., & Pellizzon G. G. (1998). The effects of muscle fatigue on shoulder joint position sense. The American journal of sports medicine, 26(2), 262-265.

Chandler T. J. (1998). Conditioning for tennis: preventing injury and enhancing performance. Science and Racket Sports II. 77-85

.

Chandler T. J., Kibler B., Stracener E. C., Ziegler A. K., & Pace B. (1992). Shoulder strength, power, and endurance in college tennis players. The American journal of sports medicine, 20(4), 455-458.

Chandler T. J., Kibler W. B., Uhl T. L., Wooten B., Kiser A., & Stone A. (1990). Flexibility comparisons of junior elite tennis players to other athletes. The American journal of sports medicine, 18(2), 134-136.

Cordo P., Carlton L., Bevan L., Carlton M., & Kerr G. K. (1994). Proprioceptive coordination of movement sequences: role of velocity and position information. Journal of neurophysiology, 71(5), 1848-1861.

Crespo M., & Miley D. (1998). Advanced coaches manual. International tennis federation, printed in Canada.

Dover G. C., Kaminski T. W., Meister K., Powers M. E., & Horodyski M. (2003). Assessment of shoulder proprioception in the female softball athlete. The American journal of sports medicine, 31(3), 431-437

Ellenbecker T., & Roetert E. P. (2003). Age specific isokinetic glenohumerel internal and external rotation strength in elite junior players. Journal of science and medicine in sport, 6(1), 65-72.

Elliot B., Reid M., & Crespo M. (2003). Biomechanics of advanced tennis. International tennis federation, printed in Spain.

Ferrauti A., Pluim B. M., & Weber K. (2001). The effect of recovery duration on running speed and stroke quality during intermittent training drills in elite tennis players. Journal of sports sciences, 19, 235-242.

Glousman R, Jobe F, Tibone J, Moynes D. (1988). Dynamic electromyographic analysis of the throwing shoulder and glenohumeral instability. Journal of bone and joint surgery, 70-A(2), 220-226.

Gooey K., Bradfield O., Talbot J., Morgan D. L., & Proske U. (2000). Effects of body orientation, load and vibration on sensing position and movement at the human elbow joint. Experimental brain research, 133, 340-348.

Groppel J. L. (1992). High tech tennis (second edition). Leisure press, USA.

Gurney B., Milani J., & Pedersen M. E. (2000). Role of fatigue on proprioception of the ankle. Journal of exercise physiology, 3(1), Retrieved from the Web http://faculty.css.edu/tboone2/asep/JEPgurney.html

Hoskins T. (2003). The tennis drill book. Human kinetics, USA.
http://www.nlm.nih.gov/medlineplus/ency/images/19622.

Janwantanakul P., Magarey M. E., Jones M. A., & Dansie B. R. (2001). Variation in shoulder position sense at mid and extreme range of motion. Archives of physical medicine and rehabilitation, 82, 840-844.

Janwantanakul P., Magarey M. E., Jones M. A., Grimmer K. A., & Miles T. S. (2003). The effect of body orientation on shoulder proprioception. Physical therapy in sport, 4, 67-73.

Jensen B. R., Laursen B., & Sjqgaard G. (2000). Aspects of shoulder function in relation to exposure demands and fatigue – a mini review. Clinical biomechanics, 15 supplement (1), 17-20.

Jerosch J., Thorwesten L., & Teigelkotter T. (1997). Proprioception of the shoulder joint in young tennis players. (abstract). Sportverletz sportschaden, 11(1), 1-9.

Johnston III R. B., Howard M. E., Cawley P. W., & Losse G. M. (1998). Effect of lower extremity muscular fatigue on motor control performance. Medicine & science in sports and exercise, 30(12), 1703-1707.

Kablan N., Ertan H., Ünver F., Kirazcı S., & Korkusuz F. (2004). Factors affecting the shoulder proprioceptive sense among male volleyball players. Isokinetics and exercise science, 10, 1-6.

Kibler W. B., Chandler T. J., Livingston B. P., & Roetert E. P. (1996). Shoulder range of motion in elite tennis players. Effect of age and years of tournament play. The American journal of sports medicine, 24(3), 279-285.

Kibler W. B., Chandler T. J., Uhl T., & Maddux R. E. (1989). A musculoskeletal approach to the preparticipation physical examination. Preventing injury and improving performance. The American journal of sports medicine, 17(4), 525-531.

König D., Huonker M., Schmid A., Halle M., Berg A., & Keul J. (2001). Cardiovascular, metabolic, and hormonal parameters in professional tennis players. Medicine & science in sports and exercise, 33(4), 654-658.

Lee H-M., Liau J-J., Cheng C-K., Tan C-M., & Shih J-T. (2003). Evaluation of shoulder proprioception following muscle fatigue. Clinical biomechanics, 18, 843-847.

Lephart S. M., & Jari R. (2002). The role of proprioception in shoulder instability. Operative techniques in sports medicine, 10(1), 2-4.

Lephart S. M., Pincivero D. M., Giraldo J. L., & Fu F. H. (1997). The role of proprioception in the management and rehabilitation of athletic injuries. The American journal of sports medicine, 25(1), 130-137.

Lephart S. M., Warner J. P., Borsa P. A., & Fu F. H. (1994). Proprioception of the shoulder joint in healthy, unstable and surgically repaired shoulders. Journal of shoulder and elbow surgery, 3, 371-380.

Magal M., Webster M. J., Sistrunk L. E., Whitehead M. T., Evans R. K., & Boyd J. C. (2003). Comparison of glycerol and water hydration regimens on tennis-related performance. Medicine & science in sport and exercise, 35(1), 150-156.

Mont M. A., Cohen D. B., Campbell K. R., Gravare K., & Mathur S. K. (1994). Isokinetic concentric versus eccentric training of shoulder rotators with functional evaluation of performance enhancement in elite tennis players. The American journal of sports medicine, 22(4), 513-517.

Myers J. B., & Lephart S. M. (2002). Sensorimotor deficits contributing to glenohumeral instability. Clinical orthopaedics and related research, 400, 98-104.

Newton R. A. (1982). Joint receptor contributions to reflexive and kinesthetic responses. Physical therapy, 62(1), 22-29.

Paterno M. V., Myer G. D., Ford K. R., & Hewett T. E. (2004). Neuromuscular training improves single-limb stability in young female athletes. Journal of orthopaedic & sports physical therapy, 34, 305-316.

Pedersen J., Lönn J., Hellström F., Djupsjöbacka M., & Johansson H. (1998). Localized muscle fatigue decreases the acuity of the movement sense in the human shoulder. Medicine & science in sports and exercise, 31(7), 1047-1052.

Powers S. K., & Edward H. T. (1997). Exercise physiology: theory and application to fitness and performance (third edition). WCB/McGraw-Hill, USA.

Rogol I. M., Ernst G., Perrin D. H. (1998). Open and closed kinetic chain exercises improve shoulder joint position sense equally in healthy subjects. Journal of athletic training, 33(4), 315-318.

Priest J. D., & Negal D. A. (1976). Tennis shoulder. Abstract. American journal of sports medicine, 4(1), 28-42.

Ryu R. K. N., McCormick J., Jobe F. W., Moynes D. R., & Antonelli D. J. (1988). An electromyographic analysis of shoulder function in tennis players. The American journal of sports medicine, 16(5), 481-485.

Safran M. R., Borsa P. A., Lephart S. M., Fu F. H., & Warner J. J. P. (2001). Shoulder proprioception in baseball pitchers. Journal of shoulder and elbow surgery, 10, 438-444.

Schmidt R. A., & Wrisberg C. A. (2004). Motor learning and performance, Human kinetics, USA.

Segal D. K. (2005). Tennis biodynamic system. Destino global sports marketing, Buenos Aires, Argentina.

Seliger V., Ejem M., Pauer M., & Safarik V. (1973). Energy metabolism in tennis. Int. Z. Angew. Physiol., 31, 333-340.

Shier D., Butler J., & Lewis R. (1996). Hole's Human anatomy & physiology. Wm. C. Brown, USA.

Smekal G., Von Duvillard S. P., Rihacek C., Pokan R., Hofmann P., Baron R., Tschan H., & Bachl N. (2001). A physiological profile of tennis match play. Medicine & science in sports and exercise, 33(6), 999-1005.

Swanik K. A., Lephart S. M., Swanik B., Lephart S. P., Stone D. A., & Fu F. H. (2002). The effects of shoulder plyometric training on proprioception and selected muscle performance characteristics. Journal of shoulder and elbow surgery, 11, 579-586.

Treiber F. A., Lott J., Duncan J., Slavens G., & Davis H. (1998). Effects of theraband and lightweight dumbbell training and shoulder rotation torque and serve performance in college tennis players. The American journal of sports medicine, 26(4), 510-515

.

Vergauwen L., Brouns F., & Hespel P. (1998). Carbohydrate supplementation improves stroke performance in tennis. Medicine & science in sports and exercise, 30(8), 1289- 1295.

Warner J. P., Lephart S., & Fu F. H. (1996). Role of proprioception in pathoetiology of shoulder instability. Clinical orthopaedics and related research, 330, 35-39.

Yildiz Y., Aydin T., Sekir U., Kiralp M. Z., Hazneci B., & Kalyon T. A. (2005). Shoulder terminal range eccentric antagonist/concentric agonist strength ratios in overhead athletes. Scandinavian journal of medicine & science in sports, 1-7.

APPENDICES

APPENDIX A

INFORMED CONSENT

TENİS OYUNCULARINDA OMUZ EKLEM VE KAS GRUBU ALGILAYICILARININ ETKİSİ

Tenis sporu, özellikle omuz kaslarında maksimum strese neden olan limitsiz tekrarı gerektiren vuruşlardan oluşur. Bu vuruşlardan, servis ve smaç, hızlı bir şekilde kolun tam olarak baş üstü açılımıyla olur. Eksantrik olan bu hareket omuz eklemine büyük yük bindirirken kas koordinasyonunu gerektirir. Yapılan araştırmalara göre, Tenis oyuncularının %50 si omuz eklem veya kaslarından şikayetçi olup, tedavileri için bu spordan belli bir süre uzak kalmışlardır. Ancak gerekli kuvveti ve kas koordinasyonunu sağlayan sporcuların bu tip şikayetleri olmamıştır.

Kaslarda ve eklemlerde bulunan bazı algılayıcılar (receptor) var ki bunlar eklem pozisyonu ve hareketin yönü hakkında bilgi verip yapılan hareketin zamanlamasını ve kas koordinasyonunu sağlarlar. Ne yazık ki, son yıllardaki bulgulara göre, hareketin doğru olup olmadığını kontrol eden ve omuz ekleminin stabilitesini sağlayan çok önemli olan bu algılayıcıların bazı etkenlerden dolayı işlevlerinde bir bozulma olduğu gözlenmiştir.

Bu etkenlerden bir tanesi de ilgili sporda kullanılan eklem ve kas grubunun sık ve yüksek şiddette kullanılmasıdır. Bilindiği üzere tenis maçları saatlerce sürebilir. Dolayısıyla oyuncuların omuz eklem ve kas grubuna fazla yük biner. Bu durum algılayıcıların (receptörlerin) işlevlerinde bozulmaya neden olabilir. Oyuncuların maçlarda bu işlevsel bozukluktan dolayın yaptıkları basit hatalar bir yana, oyuncuların sakatlanma riski artmaktadır.

ODTÜ Beden Eğitimi ve Spor Bölümü ve ODTÜ Sağlık ve Rehberlik Merkezi ortaklığında başlatılan çalışmanın amacı tenis sporuyla ilgilenen 14-16 yaş çocuklarda, omuz eklem ve kas algılayıcılarının istenilen açıyı bulup bulamamaları üzerindeki etkisini, ve baskın olan kol ile baskın olmayan kol arasında bir fark olup olmadığını tespit etmektir.

Ölçümler Biodex ile gerçekleştirilecektir. Bu yöntem oldukça basit ve güvenlidir..

Çalışmaya konuk olma süresi 2 saat ile sınırlıdır. Bu çalışma sonucunda çocuğunuzun baskın olan ve baskın olmayan kollarında algılamada bir fark olup olmadığını öğrenecek ve antrenörlerimizin çocuğunuzun gelişimi hakkında bilgi sahibi olmasını sağlayabilirsiniz. Spora bilimsel bir bakış açısıyla yaklaşan ATK, ODTÜ, ve DSİ tenis branşları antrenörlerinin « Antrenmanda Bireysellik İlkesini » uygulayabilmeleri açısından bu çalışmaya katılmanızı önerir ve sizi aramızda görmeyi arzu ederiz. Bu çalışmaya katılmayı ret etme ve istediğiniz anda bırakma hakkına sahip olduğunuzu hatırlatırız.

Bu çalışmada amacımız geleceğin büyükleri olan tenis sporuna gönül vermiş, çocuklarımızın bilinçli bir spor hayatı ile sağlıklı bir erişkinlik dönemine ulaştırabilmektir.

Velisi

İsim: İMZA

Soyadı:

İş Tel:

Ev Tel:

Cep Tel:

Adres:

e-mail:

Çocuğu

Adı:

Soyadı:

Yaşı:

Kilo:

Boy:

Kaç yıldır bu
sporla ilgileniyor:

APPENDIX B

PERSONAL INFORMATION SHEET

ODTÜ BESB ve SRM ANKET FORMU

Sayın veli, lütfen aşağıdaki soruları çocuğunuz adına cevaplayınız.

<u>Velinin</u>		<u>Çocuğun</u>	
Adı:	……………………………	Adı:	…………………….
Soyadı:	……………………………	Soyadı:	………………………
Tel(İş):	……………………………	Yaşı:	………………………
Tel(Ev):	……………………………	Boy:	………………………
Tel(Cep):	……………………………	Kilo:	………………………
Adres:	……………………………	Cinsiyeti:	………………………

e-mail: ……………………………

1- Sizde ve ailenizde (anne-baba-kardeş) herhangi bir sistematik bir hastalığı (şeker, yüksek tansiyon, kalp veya damar problemi v.b.) olan var mı?

ڤ Evet, bende …………………………. hastalığı var.
ڤ Evet, bende …………………………. hastalığı var.
ڤ Hayır

2- Düzenli olarak kullandığınız ilaç var mı?

ڤ Evet (Lütfen ilaç ismini, kullanım süresini belirtiniz)
ڤ Hayır

3- Sağ ve sol omzunuzda herhangi bir ortopedik travma (çıkık) veya cerrahi müdahale geçirdiniz mi?

ڤ Evet
ڤ Hayır

4- Lütfen antrenman programınızı yazınız.

Antrenman: Haftada………gün………saat.
Kondisyon: Haftada………gün………saat.

5- Kaç yıldır tenis oynuyorsunuz? ……. Yıl.

6- Tenis dışında uğraştığınız bir fiziksel aktivite var mı? Var ise;

…………………..ile haftada………..gün……….saat.