T.C.

YEDİTEPE UNIVERSITY

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THE IMMEDIATE EFFECTS OF SPINAL MOBILIZATION ON UPPER TRAPEZIUS MUSCLE STIFFNESS, TONE, AND ELASTICITY IN VOLLEYBALL PLAYERS

MASTER THESIS

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APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated 31.12.2021 and numbered 2021/13-48.

Prof. Dr. Bayram YILMAZ

Director of Institute of Health Sciences

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.

30.12.2021

Hande Besna GÖÇEN

DEDICATION

I would like to dedicate my thesis to my parents Ayşe and Veli GÖÇEN and my sister Şule OZAN for their lifelong support.

Hande Besna GÖÇEN

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LIST OF SYMBOLS AND ABBREVIATIONS

%	symbol of percentage
°	symbol of rotation in degrees
Cm	unit of length in centimeters
kg	unit of mass in kilograms
kg/m2	unit of body mass index
m	unit of length in meters
FIVB	International Volleyball Federation
ECC	Eccentric motor control exercise
ROM	Range of Motion
LAT	Latissimus Dorsi
BMI	Body Mass Index
MVC	Maximum voluntary contraction
PAIVMs	Passive accessory intervertebral movements
PA	Posterior- Anterior
SPSS	Statistical Package Analyze for Social Sciences

ABSTRACT

Göçen, H. B. (2021). The Immediate Effects of Spinal Mobilization on Upper Trapezius Muscle Stiffness, Tone and Elasticity in Volleyball Players, Yeditepe University, Institute of Health Sciences, Department of Sports Physiotherapy, Master's Thesis. Istanbul.

The aim of this study is to investigate the immediate effects of spinal mobilization on upper trapezius muscle stiffness, tone and elasticity in female adolescent volleyball players. 32 female athletes from Eczacıbaşı Sports Club adolescent volleyball team were included in the study. Players were randomly divided into two groups as Control Group (CG) (n = 16) and Experimental Group (EG) (n = 16). The viscoelastic properties (stiffness, tone, elasticity, creep and relaxation) of the right and left trapezius muscles of the volleyball players in both groups were measured with the MyotonPro device just before and after the applications. Athletes in the control group only performed eccentric motor control exercise as 10 repetitions and 3 sets separated by a 2-minute rest. The experimental group, besides the eccentric exercise also received spinal mobilization to the C3-C4 level. Second measurements were taken immediately after treatments. The difference between the groups and before and after spinal mobilization application were analyzed. According to the main results of this study, spinal mobilization application and eccentric motor control exercise did not have a significant effect on the viscoelastic properties of the upper trapezius muscle on stiffness, tone and elasticity values ($p>0.05$). Our findings showed a significant improvement in creep and relaxation values from the viscoelastic properties of the upper trapezius muscle in the experimental group in which spinal mobilization was applied ($p <0.05$). Therefore, we concluded that spinal mobilization may be applied to improve creep and relaxation values.

Keywords: spinal mobilization, volleyball player, MyotonPro device, viscoelastic properties, eccentric motor control exercise

ABSTRACT (TURKISH)

Göçen, H. B. (2021). Voleybolcularda Spinal Mobilizasyonunun Üst Trapezius Kas Sertliği, Tonusu ve Esnekliği Üzerine Anlık Etkileri, Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Spor Fizyoterapisi Anabilim Dalı, Yüksek Lisans Tezi. İstanbul. Bu çalışmanın amacı, kadın adolesan voleybolcularda spinal mobilizasyonunun üst trapezius kas sertliği, tonusu ve elastikiyeti üzerine anlık etkilerini araştırmaktır. Çalışmaya Eczacıbaşı Spor Kulübü genç voleybol takımından 32 kadın sporcu dahil edildi. Oyuncular randomize bir şekilde Kontrol Grubu (CG) (n = 16) ve Deney Grubu (EG) (n = 16) olmak üzere iki gruba ayrıldı. Her iki gruptaki voleybolcuların sağ ve sol trapezius kaslarının viskoelastik özellikleri (sertlik, tonus, elastikiyet, sünme ve gevşeme) uygulamalardan hemen önce ve sonra MyotonPro cihazı ile ölçüldü. Kontrol grubundaki sporcular sadece eksantrik motor kontrol egzersizi yaptı. 2 dakikalık bir dinlenme ile ayrılan 10 tekrar ve 3 set şeklinde gerçekleştirildiler. Deney grubuna, eksantrik egzersizin yanı sıra, C3-C4 seviyesine spinal mobilizasyon uygulandı. Tedavilerden hemen sonra ikinci ölçümler alındı. Gruplar arasındaki fark ve spinal mobilizasyon uygulaması öncesi ve sonrası analiz edildi. Bu çalışmanın ana sonuçlarına göre, spinal mobilizasyon uygulaması ve eksantrik motor kontrol egzersizi, üst trapezius kasının viskoelastik özelliklerinden sertlik, tonus ve elastikiyet değerleri üzerine anlamlı bir etkiye sahip değildi. ($p>0.05$). Bulgularımız spinal mobilizasyon uygulamasının yapıldığı deney grubunda üst trapezius kasının viskoelastik özelliklerinden sürünme ve relaksasyon değerlerinde anlamlı bir iyileşme gösterdi ($p <0.05$). Bu nedenle, sünme ve gevşeme değerlerini iyileştirmek için spinal mobilizasyonun uygulanabileceği sonucuna vardık.

Anahtar Kelimeler: spinal mobilizasyon, voleybolcu, MyotonPro cihazı, viskoelastik özellikler, eksantrik motor control egzersizi

1. INTRODUCTION AND PURPOSE

The sport of volleyball in general is the most popular and widespread sports in the world and is played by more than 200 million people internationally (1). It is a sport that requires many movements unique to volleyball such as blocking, dunking, jumping and lowering the ball, which requires the musculoskeletal system to do a lot in the mirror and must be combined with fast movements. As a result, volleyball players may be at great risk for musculoskeletal injuries (2).

Sports injuries are quite common in contemporary Western society. With the increase in the importance given to sports, injuries have also started to increase. It is in the first place in sports played with the ball, which causes injuries together with volleyball, basketball and football (3).

The prevalence of overuse-related injuries in volleyball sport was played an average of 0.6/1000 hours (4). However, injuries related to overuse constitute an important source of pain and disability for volleyball players who train by repeating the same technical movement over and over. Although symptoms may appear moderate and many athletes continue to play/train despite the presence of overuse conditions, knee injuries along with shoulder problems and low back pain can seriously compromise volleyball players' performance with prolonged forced rest. It takes an average of 4,096.2 weeks not to quit competitions due to an overuse injury, and the shoulder is the region with the most injuries and the longest absence time (1).

Several muscles are in charge for the dynamic stability of the shoulder joint through arm movement. Within them, the upper trapezius muscle subscribes to normal scapular motion by rotating and elevating the scapula through arm elevation (5). Electromyography studies have particularly highlighted the act of UT to stabilize the scapula and maintain adequate glenohumeral joint kinematics during shoulder abduction movement (6). For this reason, the stiffness, tone and elasticity of the trapezius muscle are very important for volleyball players.

Manual therapy is used to relief the musculoskeletal problems. Some researchers have also claimed that it could be effective to use the manual therapy in spinal cord injuries. Although it is not clear yet, the underlying mechanism of this method is explained by the changes in neurobiological condition and length of the connective tissue along with the autonomic and motor nerves. In addition, by activating the neural structure, it controls pain and stretches the connective tissues, thereby increasing the ROM (7).

Fernández-de-las-Peñas et al. established a relationship between the formation of trigger points (taut bands) in the upper fibers of the upper trapezius muscle and the presence of cervical dysfunction (hypomobility presumed when high resistance, decreased joint slippage, and abnormal tip sensation are present) at the level of the C3-C4 vertebrae. (8). Manual therapy aims to restore upper cervical mobility through many treatment methods, such as mobilization and manipulation techniques, and a wide variety of therapeutic procedures, and constitutes the treatment (9). International frameworks have been developed for methods applied, guiding the evaluation and treatment of the cervical spine region, and evidence-based methods, especially during passive joint mobilization and manipulation, focusing on techniques that occur in positions in the final range. (10).

Upper cervical spinal mobilization techniques have been demonstrated as an evidence-based and safe alternative that meets international criteria. TSM is defined as a system of manual techniques and treatment method using straight-line forces transmitted parallel or perpendicular to a single vertebral joint or motion segment (10).

Manual therapy is a treatment method that prevents injuries and speeds up the return to sports in adolescent volleyball players. Increased stiffness and decreased elasticity of the trapezius muscle is a potential problem in increasing the risk of injury. Spinal mobilizations (C3-C4 segment) made for the upper trapezius muscle that can change the stiffness, tone and elasticity of the muscle. However, studies on this subject are limited. Therefore, this study was conducted to understand the instant effect of cervical spinal mobilization techniques on upper trapezius muscle stiffness, tone and elasticity in adolescent volleyball players.

The hypotheses of our study;

H0. Spinal mobilization has no significant effect on the stiffness, tone and elasticity properties of the upper trapezius muscle in adolescent volleyball players.

H1. Spinal mobilization has a significant effect on the stiffness, tone and elasticity properties of the upper trapezius muscle in adolescent volleyball players.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. Functional Anatomy of Shoulder

Shoulder joint complex has the largest ROM of the body. The shoulder girdle complex is constituted of three bones. These are the scapula, the humerus, and the clavicle (Figure 1). They are attached to either to one another or trunk via the ACJ, the STJ, the GHJ, and the STJ (11).

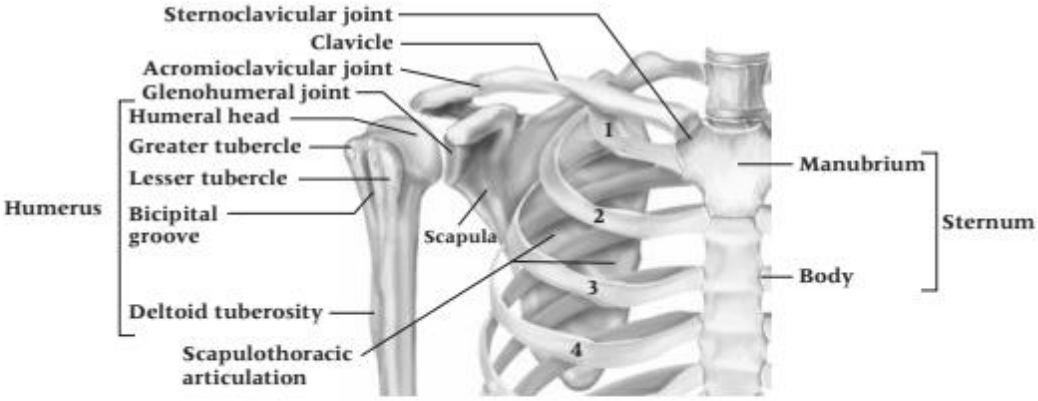

Figure 1. 1 The shoulder complex joint

2.2. Joints of Shoulder Complex

Glenohumeral joint (GHJ)

The glenohumeralis is a spheroid type joint formed between the caput humeri and the cavitas glenoidalis. The glenohumeralis is the joint that allows the maximal range of motion of the joints in the body (12). Stabilization of the joint, unlike other joints, is provided by the rotator cuff muscles (teres minor muscle, infraspinatus, subscapularis, and supraspinatus muscles) rather than intra-articular negative pressure (13). Ligaments of the joint; capsula articularis, ligg. glenohumeralia, lig. coracohumerale, lig. transversum humeral (12). These structures provide the static stability of the joint. It allows adduction, abduction, flexion, and extension. It also allows internal rotation, external rotation and circumduction movements (14)

Acromioclavicular joint (ACJ)

Acromioclavicularis is a planar type joint between the os clavicula and the os acromion (15). ligaments of the joint; capsula articularis, lig. coracoclaviculare, acromioclaviculare lig, lig. conoideum, lig. trapezoideum, and discus articularis (12). It allows protraction, retraction, rotation, elevation and depression movements of the os scapula (14).

Sternoclavicular joint (SCJ)

The sternoclavicularis is a sellar type joint between the os clavicula and the os manubrium sterni. It is the just joint that establishes the connection between the trunk and the upper extremity (16). ligaments of the joint; capsula articularis, lig. sternoclaviculare anterius and posterius, lig. costoclaviculare, lig. interclaviculare and discus articularis (12). It allows protraction, retraction, elevation and depression movements (14).

Scapulothoracic joint (STJ)

Art. scapulothorasicus is located between m. subscapularis and m. serratus anterior muscles (12). This is not an anatomical joint as it does not form a connection between the scapula and the thorax. It allows flexion and abduction movements of the arm (14).

2.3. Muscles of Shoulder Complex

M. Deltoideus

It consists of three parts, front, middle and back. The anterior part originates from the distal 1/3 of the clavicle, the middle part starts from the acromion head, and the posterior part originates from the posterior part of the spina scapula. All three parts attach to the tuberositas deltoideus. The anterior part makes the shoulder flexion, abduction and internal rotation, the middle part abduction, and the posterior part extension, abduction and external rotation (17, 18).

M. Pectoralis Major

The pectoralis major muscle, which consists of the clavicular and sternal parts, is one of the large muscles of the chest. The clavicular segment begins medial 1/3 of the clavicle and attaches to the lateral border of the bicipital groove of the humerus. The sternal part starts from the cartilage of the first 6 ribs and the sternum and attaches to the same place as the clavicular part. The muscle crosses the joint anteriorly from medial to lateral, thus adduction and internal rotation (9).

M. Latissimus Dorsi

It is a large sheet-shaped muscle located on the back. It starts from the spinous process (dorsolumbal fascia) of the T7-L5 vertebrae, the posterior surface of the iliac crest, the sacrum, and the last three ribs. It attaches medially into the bicipital groove of the humerus. It causes extension, internal rotation and adduction of the shoulder (19).

M. Teres Major

It begins at the axillary border of the inferior angle of the scapula. It attaches below the insertion site of the latissumus dorsi and the small tubercle. It provides adduction, extension, and internal rotation of the shoulder (19).

M. Coracobrachialis

It adjoins from the process of the coracoid of the scapula to the medial surface of the humerus near the midpoint. It stabilizes the shoulder joint (19).

M.Biceps Brachii and M.Triceps Brachii

They are two joints muscles that span both the elbow and the shoulder. Its main functions are in the elbow. The most important tasks of the biceps muscle are to supinate and flex the forearm. It also aids in the elevation of the upper extremity. The main task of the triceps muscle is to extend the forearm. The long head additionally adducts and extends the arm (19).

Rotator Cuff Muscles

These muscles play a significant role in stabilizing the glenohumeral joint (18).

M. Infraspinatus

It originates from the fossa infraspinata in the scapula. It connects to the greater tubercle of the humerus. It causes external rotation and horizontal abduction of the upper extremity (17, 19).

M. Supraspinatus

It originates from the supraspinatus fossa in the scapula. It connects to the greater tubercle of the humerus. It abducts the upper extremity and pulls the humerus towards the glenoid cavity (17).

M. Teres Minor

It originates from the axillary boundary of the scapula. It connects to the greater tubercle of the humerus. It causes external rotation and horizontal abduction of the upper extremity (19, 17).

M. Subscapularis

It originates from the fossa subscapularis on the anterior surface of the scapula. It connects to the small tubercle of the humerus. It causes internal rotation of the upper extremity (17, 19).

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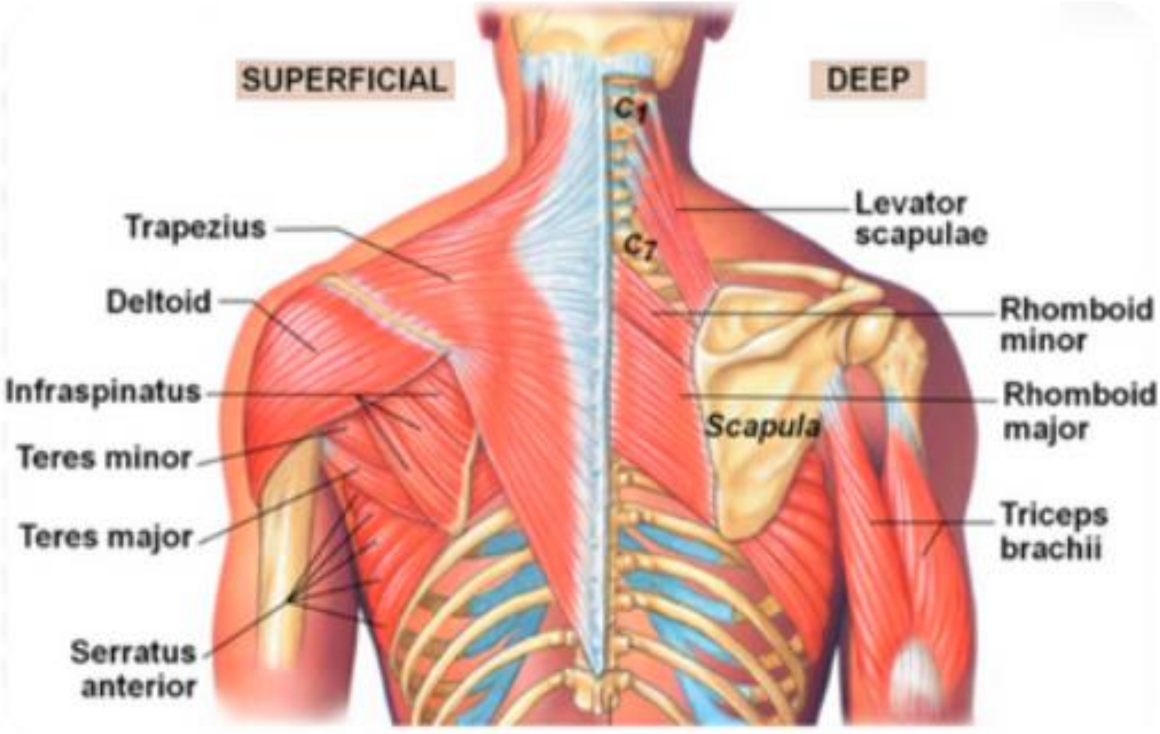


Figure 1.2 The Muscules of shoulder complex

M. Trapezius

Its upper part originates from the upper cervical vertebrae's nuchal ligament and the occipital protuberans. The nuchal ligament is associated with the spinous process of the upper cervical vertebra. It terminates lateral to the acromion and at the clavicle. It makes upward rotation and scapular elevation.

Its middle part originates from the lower cervical vertebrae's the nuchal ligament and the processes of spinous of the upper thoracic vertebrae and C7. It attaches medial to the acromion and the spina to the scapula. It makes scapular retraction.

Its lower part originates from the spinous process of the lower and middle thoracic vertebrae and attaches to the spina scapula. It causes scapular depression and upward rotation (19).

M. Levator Scapula

It starts from the process of transverse of the initial four cervical vertebrae. It insists to the vertebral boundary of the scapula between the spine and the upper angle of the scapula. It pulls the scapula up and rotates it downwards (19).

M.Rhomboideus

The rhomboid consists of two muscles, minor and major. They are often noted together because it is hard to separate the two muscles anatomically and their functions are usefully the same. They originate from the spinous processes of the C7-T5 vertebrae. They attach to the vertebral border of the scapula between the inferior angle of the spine and the scapula. They cause scapular retraction, elevation, and downward rotation (19).

M. Serratus Anterior

It starts from the lateral surface of the upper 8 ribs. It attaches to the anterior surface and medial edge of the scapula. It makes the scapular protraction and upward rotation (19).

M. Pectoralis Minor

It starts from the anterior superficial of the third and fifth ribs. It attaches to the process of corocoid of the scapula. It causes scapular protraction, depression, tilt and downward rotation (19).

2.4. Shoulder Biomechanics and Kinematics

The upward movement of the humerus in the frontal (abduction), sagittal (flexion) and scapular (scaption) planes is called elevation of the shoulder joint. In order for this movement to be of good quality, the glenohumeral, scapulothoracic, acromioclavicular and sternoclavicular joints must work in harmony (19, 20). Completion of shoulder elevation depends on the compatibility between the glenohumeral joint and the scapulothoracic joint. The first 30° shoulder movement is absolute glenohumeral joint movement. For every 2° of shoulder abduction or flexion that occurs after 30 degrees of elevation, the scapula should be rotated upwards by 1°. This 2:1 rate is known as the scapulohumeral rhythm (19, 21). In later studies, it has been shown that this rate varies at different angles (22-24).

During the first 90° of elevation in the abduction direction, 60° abduction of the glenohumeral joint and 30° upward rotation of the scapulothoracic joint occur. 5-10° upward elevation at the acromioclavicular joint and 20-25° clavicular elevation at the sternoclavicular joint occur with this movement. In the next 90° abduction, the glenohumeral joint and the scapulothoracic joint move at the same rate. Clavicle rotates 40° posteriorly, elevates 5°. 20-25° upward rotation occurs at the acromioclavicular joint. One hundred and eighty degrees of complete abduction is completed with 60° scapulothoracic joint rotation, 30° acromioclavicular joint upward rotation, and 30° sternoclavicular joint elevation (25, 26).

In summary, the first 30° abduction is actually the effect of glenohumeral movement. Movement from thirty degrees to full upper extremity abduction occurs at the glenohumeral joints and scapulothoracic joints. Movement of the scapula is actually the product of movement of the acromioclavicular and sternoclavicular joints (26). A equal relationship occurs if the upper extremity is elevated in the flexion direction. Medial rotation of the humerus goes with shoulder flexion (27-29).

2.5. Volleyball

Discovered by William Morgan in 1895, it is one of the most popular types of sports played by athletes and sedentary of all age categories for professional, amateur and recreational purposes (30). Volleyball, on the other hand, is an intermittent sport in which athletes frequently perform high-intensity movements and are followed by low-intensity movement circuits (31). The aim of the game is to ensure that the ball sent over the net comes into contact with the ground in the opposing team's court, and to prevent the ball sent over the opposing team's net from contacting the ground within the boundaries of the field (32).

Volleyball is played with a leather-covered ball measuring 16.5 cm and weighing 196-280 gr in accordance with the standards of the International Volleyball Federation (FIVB). It is played on a rectangular field measuring 18x9 m, divided into two by a net of 2.43 m for men and by a net of 2.24 m for women (30).

Teams consisting of a maximum of 12 players, with 6 players on the field and 6 players in reserve, start the game with a serve. Each team can touch the ball up to 3 times, not including the block. The team that achieves 25 points first with a margin of at least 2 points wins a set. If a 24-24 tie occurs, the game is extended to 26 and the game continues until the two-point gap is reached. The team that wins 3 sets in total wins the game. If there is a 2-2 draw in sets, the team that achieves 15 points initial with a margin of minimum 2 points wins the game (30).

Basic Techniques and Biomechanics in Volleyball

Volleyball hitting techniques include serve, service receiving, finger pass, dive and dive & roll, block and dunk movements (30).

2.5.1. Service

The serve is the first technical move that starts the game. Services can be sent in two ways, overhead and under head (30). The most used types are flot (tennis) and dunk serve (33). In the flot (tennis) service, the non-dominant side is in front of the foot, the non dominant side is in the hand with the ball in 90 degrees flexion, and the body is in slight rotation and facing the side where the ball is to be thrown. By making the trunk extension, the ball is thrown into the air and by taking a step, the ball is hit with the dominant side and sent in the form of a glide (33, 34). In the dunk serve, the ball is held by the dominant hand. It is thrown forward and upwards and the dominant side takes 4 steps with the foot, then jumps and hits the ball violently with the palmar side of the hand (Figure 2.1). Hitting the ball fast, good arm swings and accurate shooting increase the success of the serve (34).

Figure 2.1. Service

2.5.2. Service Receiving (Service Reception, Bumping)

The service receiving is generally used when receiving the service, defending against the attack of the opposing team, and passing the ball between players (30). It is important to take a position before the bumping. The spine has a 45 degree slant with the ground. Hips back, feet shoulder-width apart and knees slightly flexed. Shoulders in protraction, forearm in supination, elbows locked in extension, hands and arms joined in front of the body. The athlete transfers his weight to the side where the ball comes from and extends his arms (35) (Figure 2.2).

Figure 2.2. Service Receiving (Bumping)

2.5.3. Overhand Finger Pass

The finger pass is used to meet low-intensity serves, to make a pass between the players, and to throw the ball to the opponent's side when the game cannot be established (30).

Stand with feet side by side or one foot in front. The knees are semiflexed and the spine is straight. The hands are slightly above eye level and 15-30 cm in front of the head (33, 34). Elbows have at least 90 degrees of flexion. After the fingers touch the ball, the whole body transfers energy to the upper extremity. With the ulnar deviation occurring in the wrist, the ball is sent (33, 34) (Figure 2.3).

Figure 2.3. Overhand Pass

2.5.4. Dive and Dive & Roll

The dive-dive and roll is a technique that the player uses to recover balls that are far away and cannot be saved by finger pass and service receiving (30). In order to lift the ball with movements such as prone crawling or rolling on its side, weight is transferred to the foot positioned in the direction of the ball falling, and the arm is extended to the underside of the ball so that it does not touch the ground and is ventilated (36) (Figure 2.4).

Figure 2.4. Dive – Dive & Roll

2.5.5. Block

Blocking is the first phase of team defense to prevent the ball from passing over the net during the opposing team's attack (37). With the feet open at shoulder level and the palmar side of the hand facing the opponent, this is the preparation phase of the block. During the opposing player's kick, the hip is brought and the athlete jumps upwards. Generally, the athlete, who brings his arms together in the elbow extension position and extends them towards the ball, tries to prevent the ball from crossing the net (37) (Figure 2.5).

Figure 2.5. Block

2.5.6. Spike (Attack Hit)

Spike is an offensive technique that is difficult to implement, takes time to train, and requires a strong kick to pass the ball over the net to the opposite side during attack (37) (Figure 2.6). The preparatory step is the general cycle of the slam dunk, approaching the ball, breaking the ground in the final step, rising, opening back, closing forward, contacting the ball, and hitting the ground (30). Although this cycle is generally in this order, it may vary during the game with factors such as player position, ball position, and field placement (30). While raising the arm, the arm elevates more than 90 degrees and the shoulder takes a slightly horizontal abduction position. Abduction and external rotation reach their maximum value during arm swing back. During acceleration, when the hand comes into contact with the ball, the shoulder quickly performs internal rotation and adduction. After touching the ball, the extremity begins to slow down until the arm descends to the side of the trunk (38). During this deceleration, the striking shoulder continues adduction and internal rotation to reduce arm momentum and dissipate kinetic energy that is not transferred to the ball (38).

Figure 2.6. Spike

2.6. Manual Therapy

Manual therapy is often used as a treatment modality for many types of pain, such as low back pain, cervical pain, and myofascial pain syndrome (39). However, some researchers have also applied it to pathologies resulting from spinal cord injuries. This therapy can alter the neurobiological condition and it can alter length of the connective tissue along with the motor and autonomic nerves. In addition, it activates the neural structure and lengthens the connective tissues, thus increasing the ROM and can control pain to a great extent (39).

Researchers found a relationship between trigger points in the upper fibers of the trapezius muscle, one of the shoulder girdle muscles, due to overuse and cervical dysfunction at the level of the C3-C4 vertebrae (40).

Manual therapy aims to restore upper cervical mobility with a wide variety of therapeutic ways such as treatment method, mobilization and manipulation techniques, thus preventing pathologies to occur (41). International frameworks have been developed to guide the evaluation and treatment of the cervical spine region, with a particular focus on techniques performed in the final range positions while performing passive joint mobilization and manipulation (42). UC-TSM techniques have been recommended as a safe technique and treatment method that meets international criteria. TSM is defined as techniques using straight-line forces transmitted parallel to or perpendicular to a single vertebral joint segment of motion (43).

Certain muscles manage the dynamic stability of the shoulder joint complex during arm movement. Of these, the upper trapezius (UT) muscle contributes to normal scapular motion by raising and rotating the scapula during arm elevation (44). EMG studies have highlighted the major role of UT in stabilizing the scapula through shoulder abduction and maintaining adequate glenohumeral joint kinematics (45). For this reason, the stiffness, tone and elasticity of the trapezius muscle are very important for volleyball players.

Manual therapy is a treatment method that prevents injuries and speeds up the return to sports in volleyball players. Increased stiffness and decreased elasticity of the trapezius muscle is a potential problem in increasing the risk of injury. Spinal mobilizations (C3-C4 segment) made for the upper trapezius muscle can change the stiffness, tone and elasticity of the muscle. However, studies on this subject are limited.

Therefore, the aim of the study is to research the instant effects of spinal mobilization on upper trapezius muscle stiffness, tone and elasticity in volleyball players. Experimental group and control group will receive eccentric motor control exercise. Also the experimental group will receive spinal mobilization C3-C4 for upper trapezius. Our hypothesis is; there will be significant improvements in the stiffness, tone and elasticity of upper trapezius muscle in the experimental group in proportion to the control group.

2.7. Spinal Mobilization

Although manual therapy is an old treatment method, it has been frequently preferred in recent years with mobilization applications that reduce symptoms and increase shoulder mobility. Although there are manipulative applications of different intensities, Maitland defined the procedure as the slip and traction effect of a passive force applied from the outside (46).

The purpose of this method; to provide restructuring, to destroy the pathological cross bridges formed in the tissues and to increase the load capacity of the tissue and to return the person to his daily or sports life as soon as possible (47).

Manipulative applications have not only mechanical effects, but also neurophysiological effects. It creates a proprioceptive effect by stimulating the mechanoreceptors in the application area. This situation increases the development of normal sensory and motor patterns (48).

2.8. Myoton®PRO Digital Palpation Device

MyotonPRO is a mobile, removable handheld myotonometer. This tool is non-invasive and provides a quantitative evaluation of the viscoelastic features of a muscle. These features are characterized by various parameters such as stiffness, tone, and elasticity (49,50). MyotonPRO provides the skin with a short (15 ms), low intensity (0.58 N) mechanical action on the muscle. The response of the touch then generates a recorded signal and an internal software program generates an acceleration graph. Measures of various viscoelastic muscle features such as stiffness, tone, and elasticity are then extracted from this graph (51). Some studies have investigated the reliability and validity of the Myoton myotonometer to measure the viscoelastic features of skeletal muscles in various populations. These studies focused on measuring the viscoelastic features of the whole muscle with measurements taken on the muscle core. These studies evaluated moderate to excellent intra-rater and inter-rater correlation coefficients ranging from 0.67-0.99 (52.53.54) for inter-rater reliability and 0.62-0.96 for inter-rater reliability showed reliability between (52,54,55).

Figure 2.7. Myoton®PRO Digital Palpation Device

2.9. Trapezius Muscles Eccentric Motor Control Exercises

In today's elite athletes, resistance training is at the forefront for excellent performance. In order to maximize the stimuli in these studies, it is necessary to work with eccentric muscle activities as well as concentric and isometric during weight training (56).

Due to the distinctive features of eccentric training, this training model may provide an additional contribution to strength and performance in the athletic population (56).

2.10. Eccentric Exercise Training Effects

Compared to concentric exercises, eccentric exercises have the potential to overload the musculature with very low energy costs (57). This makes eccentric training a more preferable supplementary training in strength and conditioning programs to improve performance or prevent injury in elite sports (58).

It is known that eccentric resistance exercise is more beneficial in increasing strength when measuring in eccentric and concentric situations.

Studies show that eccentric exercise training can increase maximum strength in trained elite athletes. Most, but not all, studies have shown that explosive forces increase with eccentric training (59).

Eccentric exercise training can be used to improve muscle coordination. When comparing concentric muscle contractions with eccentric muscle contractions, eccentrics require different activation strategies by the central nervous system, as well as different activation programming processes (60). Electroencephalographic evaluations clearly show that cortical activation is higher in amplitude and area size during eccentric tasks (61).

3. MATERIALS AND METHODS

3.1. Subjects

The universe of our research consists of adolescent female volleyball players (13-18 years old) playing volleyball in Turkey. Our research was carried out in Eczacıbaşı Sports Club's own volleyball courts in Istanbul, under pandemic conditions. The volleyball players are elite athletes who have been playing volleyball professionally for at least two years. They have a training frequency of at least 3-4 times a week.

The sample size of the study was calculated by; using the GPower program, the type 1 error value was α= 0.05, Power (1-β) = 0.83, and the effect size d were taken as 1.15 according to moderate reference article. The population averages of the experimental and control groups were determined as at least 11 experimental and 11 control subjects. (62). A total of 32 professional adolescent volleyball players participated in the study. 16 athletes were in the control group and 16 athletes were in the experimental group.

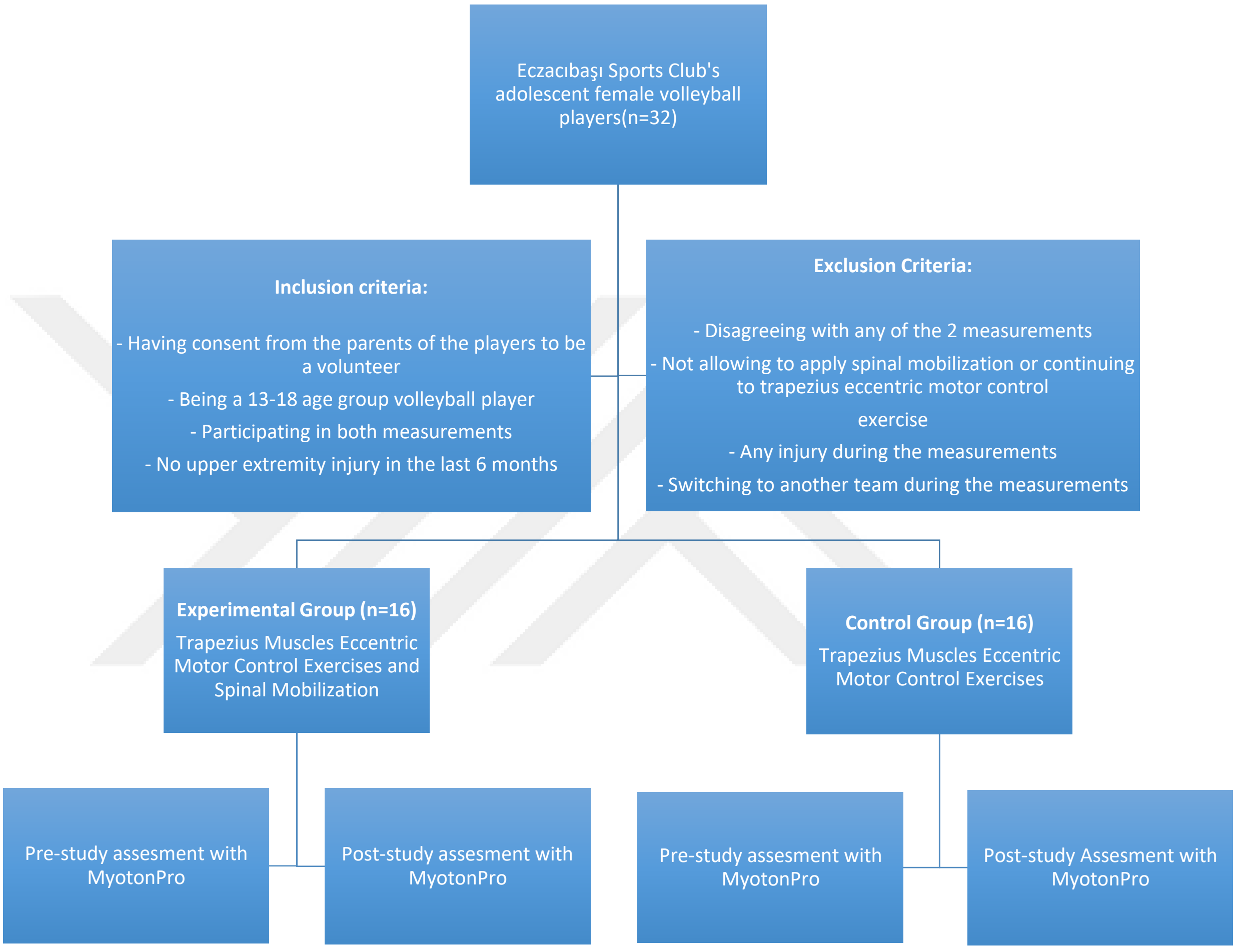
3.1.1. Inclusion criteria

- Having consent from the parents of the players to be a volunteer
- Being a 13-18 age group volleyball player
- Participating in both measurements
- No upper extremity injury in the last 6 months

3.1.2. Exclusion Criteria

- Disagreeing with any of the 2 measurements
- Not allowing to apply spinal mobilization or continuing to trapezius eccentric motor control exercise
- Any injury during the season
- Switching to another team during practice

3.1.3. Flow of Research



3.1.4. Procedure

All volunteer participants were asked to answer a demographic information survey. In the questionnaire, the age, height, weight, years of sports experience, weekly exercise frequency, and any injury history of the participant were questioned. A written parental consent form and informed voluntary consent form was obtained from each participant. The purpose and plan of the study were explained to the participants.

The study applied to volleyball players during the inter-season period. As a randomization method, the participants distributed to the spinal mobilization group or control groups by using the simple randomization method with a computer-based program (www.randomizer.org).

The dependent variable of the study was the stiffness, tone and elasticity properties of the trapezius muscle; the independent variables were spinal mobilization techniques and trapezius eccentric motor control exercise.

In the study, there were two groups as control and experimental group. The stiffness, tone, elasticity, creep, and relaxation of the athlete's right and left upper trapezius muscles were measured with the MyotonPro device. Afterwards, the athlete did eccentric motor control exercise with theraband. The exercise protocol comprises 30 ECCs performed in three sets of 10 contractions at maximum voluntary contractions (MVC) with 2 minutes of rest on the dominant side. 30 repetitions were performed by athletes. Right and left upper trapezius muscles were measured again after the exercise. Different from the control group, spinal mobilization was performed to the C3-C4 level after the exercise in the experimental group. And upper trapezius muscle after spinal mobilization was re-measured with MyotonPro device for viscoelastic features.

3.2. Methods

3.2.1. Structured Questionnaire for Demographic Features of Participants

The demographic characteristics questionnaire was filled in face to face by the researchers. The questionnaire included age, gender, body mass index (BMI), and it has also height, weight, dominant hand questions. The other part of the questionnaire has years of sports experience, weekly exercise frequency, and any injury history of the adolescent participant.

3.2.2. MyotonPro Measurement

Measurement of the upper trapezius muscle frequency, stiffness, tone, creep, and relaxation

The viscoelastic features of the upper trapezius muscle on the side of the dominant hand were evaluated (63, 64). Each participant was asked to sit on a chair. A neutral position of the shoulder joints and head was provided. In this position, the forearm was positioned in a neutral angle (in between pronation and supination) without any axial rotation in shoulder joint, and the elbow was fully extended.

As a shoulder abduction may cause an increase in the muscle stiffness of upper trapezius, abduction was limited during measurements (64). A plastic universal goniometer was used to measure the shoulder flexion angle. The measurement site of the upper trapezius muscle was determined as the midpoint between the seventh cervical process of spinous and the acromion angle (65). To cohere the same testing side within the measurements, the location of the measurement site is marked on the skin with a pencil. While measuring the trapezius muscle stiffness, the MyotonPRO probe was held perpendicular to the skin. The device uses 5-pulse multi-scan mode at 1 second intervals for testing. An average of consequent three measurements were recorded and used for further analysis.

Figure 3.1. MyotonPro measurement of right upper trapezius muscle

Figure 3.2. MyotonPro measurement of left upper trapezius muscle

3.2.3. Viscoelastic Features

Evaluation of Muscle Viscoelastic Properties

Myoton®PRO digital palpation tool is an evidence-based Class 1 device (MDD Annex IX) that evaluates the viscoelastic properties of soft biological tissues in a reliable, non-invasive, objective, inexpensive, easy and fast way. In the literature, the viscoelastic properties was found to be excellent for intra- and inter-evaluator reliability (ICC: 0.925-0.984 and 0.918-0.972, respectively) and good to excellent for test-retest reliability (ICC: 0.770-0.875) (66).

Myoton® PRO is used to evaluate connective tissues such as tendons and ligaments, superficial skeletal muscles, and other soft tissues used in research. It is a very dependable method for assessing muscle stiffness, tone, elasticity, relaxation and creep.

Figure 3.3. Myoton® PRO

Viscoelastic tissue parameters evaluated with MyotonPRO

MyotonPRO measures tissue displacement, velocity and acceleration. Five different viscoelastic tissue parameters are obtained from these data (67).

Frequency (Tonus) (Hz): The tone of muscle is described by frequency of muscle or oscillation frequency. It indicates tension in the muscle. It assesses the tone that the muscle is at resting position.

Elasticity (D): It is the capability of the muscle to repair its first shape after contraction. The logarithmic reduction in oscillations results in better muscle elasticity and contractility.

Stiffness (N/m): It is the capability of the tissue to repair its former shape after the removal of the external force moving on the muscle. Muscle stiffness is the biomechanical feature of a muscle.

Relaxation (ms): Expresses the relaxation time of mechanical stress. Mechanical stress relaxation time (ms) is the time it takes for a muscle to regain its shape from impairment after a voluntary contraction or removal of an external force.

Creep (r): It is the moderate elongation that takes place over time in a muscle under a constant tensile stress (68). Muscle strain is indicated as the ratio of the MSR time and the time to case maximum impairment by an external force.

MyotonPRO was utilized to evaluate the viscoelastic properties of trapezius muscles before and after application. The measurement was made by marking the middle of the trapezius muscles.

Figure 3.4. Ready-to-measure device

3.2.4. Trapezius Muscles Eccentric Motor Control Exercises With Theraband

Eccentric motor control exercises consisted of 30 repetitions performed in three bouts of 10 contractions at maximum voluntary contraction (MVC) with a 2-minute rest (62). The participant stood in an upright position facing forward. Her dominant hand gripped the theraband tightly. She pressed the other end of the theraband with her foot. With the shoulder in the 0 degree flexion position, she pulled the theraband up and then released it. It provided eccentric contraction and relaxation of the upper trapezius muscle.

During the exercise, participants were instructed to resist the vertical force generated by the theraband along shoulder height.

Viscoelastic properties were evaluated with the MyotonPro tool before and after the trapezius eccentric motor control exercise was performed by the participant with the dominant side. For comparison, the right and left upper trapezius muscles were measured with the MyotonPro for viscoelastic features before and after the exercise.

Figure 3.5. Eccentric motor control exercise start

Figure 3.6. Eccentric motor control exercise finish

3.2.5. Spinal Mobilization

Inspection of the cervical joints is done as defined by Maitland 3. Passive accessory intervertebral movements can be evaluated in the sitting position as well as in the prone position (69).

Some researchers expressed manual evaluation following the guidelines explained by Maitland3 as “excellent” mediator agreement in defining upper cervical joint dysfunction (k=0.78-1.00) and “excellent” agreement in appointing the level of dysfunction (k=0.25-1.00). This is how we noted the level and side of any identified hypomobility.

C3-C7 segments were measured. First, PA pressures were applied to the spinous process of all cervical vertebrae (central PAIVM). If central joint hypomobility was detected, PA pressures were also applied to the entire zygapophyseal joint (left and right) of all cervical vertebrae (unilateral PAIVM) to determine which side was causing motion restriction. The therapist evaluated the final feel of the PA and the quality of the resistance. It also evaluated the patients complained. When a vertebra was faced with the reproduction of the patient's complaint, it exhibited an early sense of end, a high quality of resistance, and hypomobility (69).

3.2.6. Mobilization of the Cervical Spine

For neck mobilization, the patient was placed in a sitting position with the back supported on the chair, the patient’s head in the neutral position, the arms free and the feet on the ground.

Since the first cervical vertebra was rarely palpable, mobilization of the first vertebra was done with the tip of the thumb pads. The first cervical vertebra was mobilized. The second and third cervical vertebrae were palpated by asking the person to flex their head slightly more (70).

The spinous process of the patient's C3 and C4 neck vertebrae was marked. The treated thumb was placed on the marked points and rhythmic thrusts were applied, while the other hand supported the head or opposite shoulder to balance and stabilize the applied force. It was defined as IV+ by Maitland at the time of the endpoint sense application (70).

Unilateral central mobilization was given only 2-3 cm lateral to the spinous process versus a joint process. Each of the C3-C4 segments was mobilized for 3 minute (70).

Figure 3.7. Spinal mobilization application

3.3. Statistical Analysis

SPSS (version 22.0) was used in the information analysis of our research. Quantitative data to be obtained from the research was shown as mean and standard deviation. Kolmogorov-Smirnov and Shapiro Wilks tests were used to test numerical variables for normality. According to the conformity of the obtained data to the normal distribution; if the data were normally distributed (parametric), Independent Sample t-test was used to compare the two groups. If the information were not normally distributed, Mann-Whitney U test was used to compare the two groups. If the data were normally distributed, the Paired Sample t-test were used to compare the before-after data of the two groups, and if the data were not normally distributed, the Wilcoxon test was used to compare the before-after data of the two groups. Qualitative data of the groups were displayed with frequency and percentage values. The statistical significance grade was accepted as $p<0.05$.

4. RESULTS

4.1. Descriptive Characteristics of Participants

The study included volleyball players (n=32, 32F) registered as a team player at Eczacıbaşı Sports Club. All participants were female. 16 of the volleyball players were in the control group, 16 of the volleyball players were in the experimental group. The number of volleyball players was determined as a minimum of 22 with the power analysis before the study. However, 10 more people were included in the study in order to make the data of the study stronger.

The demographic information (weight, height, age, BMI) of groups were demonstrated in Table 4.1. According to these findings, there were no statistical difference in two groups in terms of weight, height, and BMI ($p>0.05$). However, a statistical difference was found in age and experience time (year) between CG and EG according to Mann Whitney U test ($p<0.05$).

Table 4.1. Physical Features of Participants

	CG (n=16) Mean ± SD	EG (n=16) Mean ± SD	T	p value
Age(year)	15.31 ± 1.19	14.13 ± 1.25	-2.53	**0.011***
Weight (kg)	64.00 ± 7.31	60.69 ± 7.84	1.23	0.226
Height(m)	1.81 ± 5.72	1.77 ± 9.09	-1.38	0.168
BMI(kg/m^2)	19.32 ± 1.80	19.21 ± 1.28	0.18	0.851
Sports Experience (Year)	5.88 ± 2.41	4.00 ± 2.00	2.390	**0.023***

Data expressed as mean ± standard deviation.n: number of participants. kg= kilogram. m: meter. BMI: Body mass index. CG: Control Group, EG: Experimental Group. Mann Whitney U test *p<0.05

The dominant hand in the study groups were given Table 4.2. As a result of the statistical analysis of these values, no statistical difference was found between the two groups (p>0.05).

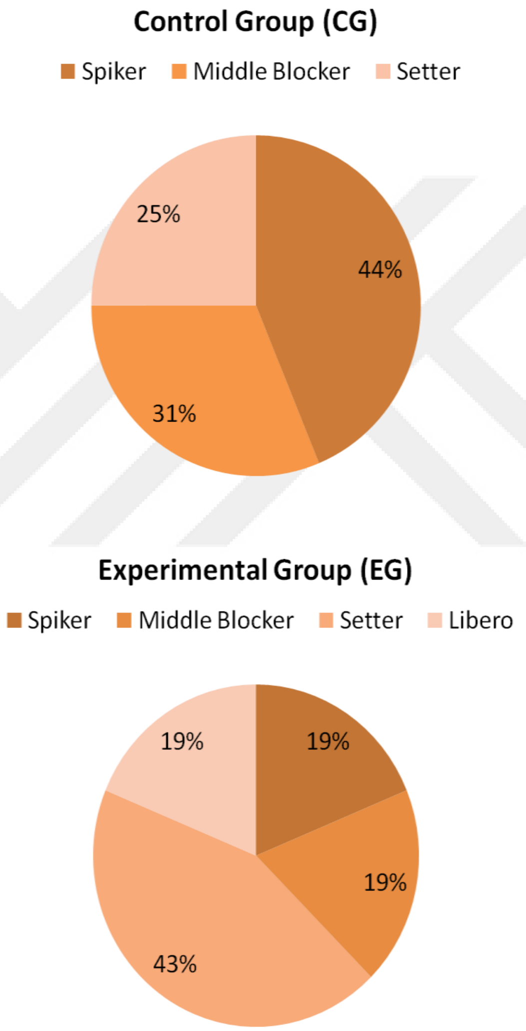
Table. 4.2. Comparison of Dominant Side of Hand among the two groups

		CG % (n)	EG % (n)	λ²	p value
Dominant hand	**Right**	75 (12)	87.5 (14)	12.50	0.503
	Left	25(4)	12.5 (2)		

Data expressed as % (n). CG: Control Group, EG: Experimental Group.

The distribution of sports positions among the control and experience groups was given Graph 4.1. According to findings, there were 7 spikers, 5 middle blockers and 4 setters players in CG, 3 spikers, 3 middle blockers and 7 setters players in EG (Graph 4.1.).

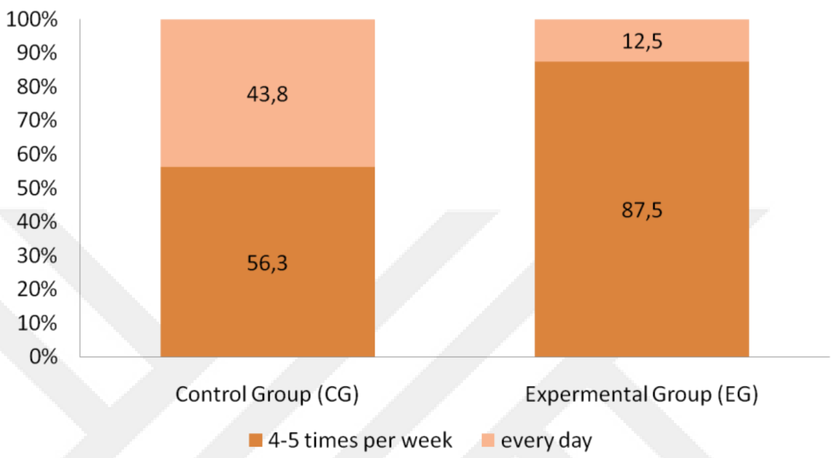
Graph 4.1. Distribution of Sports Positions among the groups



Data expressed as %. CG: Control Group, EG: Experimental Group

While 9 of the volleyball players in the control group train 4-5 times a week (%56.3), 7 of them train every day (%43.8). In the experimental group, 14 of the volleyball players train 4-5 times a week (%87.5), while 2 of them train every day (%12.5) (Graph 4.2.).

Graph 4.2. Distribution of Training Frequency Percentage among the groups



Data expressed as %. CG: Control Group, EG: Experimental Group

4.2. Intergroup Comparison of Pre-Measurement Findings

The Independent Samples t Test for parametric variables were used and the Mann Whitney U Test for nonparametric variables were used to compare variables between participants of the all group pre and post measurements.

4.2.1 Intergroup Comparison of Pre-Measurement Findings for Viscoelastic Features (Frequency, Stiffness, Decrement, Creep, and Relaxation)

As a result of the statistical analysis, no significant difference was found between the pre-measurements of groups for right and left trapezius in terms of values of Frequency, Stiffness, Decrement, Creep, and Relaxation (p>0.05) (Table 4.3 and Table 4.4).

Table 4.3. Intergroup Comparison of Pre-Measurement Findings for Right Trapezius Viscoelastic Features (Frequency, Stiffness, Decrement, Creep, and Relaxation)

	CG (n=16) Mean ± SD	**EG (n=16) Mean ± SD**	**T**	**p value**
Frequency (Hz) Right Pre-Study	18.03 ± 1.84	17.66 ± 1.70	0.583	0.564
Stiffness (N/m) Right Pre-Study	334.70 ± 63.82	324.72 ± 44.85	0.511	0.613
Decrement (D) Right Pre-Study	0.885 ± 0.092	0.878 ± 0.096	0.195	0.847
Creep (C) Right Pre-Study	0.88 ± 0.10	0.90 ± 0.12	-0.113	0.910
Relaxation (ms) Right Pre-Study	14.77 ± 2.11	15.05 ± 2.33	-0.188	0.851

Data expressed as mean ± standard deviation. CG: Control Group. EG: Experimental Group.

Table 4.4. Intergroup Comparison of Pre-Measurement Findings for Left Trapezius Viscoelastic Features (Frequency, Stiffness, Decrement, Creep, and Relaxation)

	CG (n=16) Mean ± SD	**EG (n=16) Mean ± SD**	**T**	**p value**
Frequency (Hz) Left Pre-Study	17.66 ± 1.70	14.13 ± 1.25	0.340	0.736
Stiffness (N/m) Left Pre-Study	1.81 ± 5.72	1.77 ± 9.09	0.205	0.839
Decrement (D) Left Pre-Study	0.95 ± 0.13	0.90 ± 0.10	1.097	0.282
Creep (C) Left Pre-Study	0.83 ± 0.10	0.83 ± 0.11	-0.22	0.982
Relaxation (ms) Left Pre-Study	13.74 ± 1.90	13.83 ± 2.20	0.00*	1.00

Data expressed as mean ± standard deviation. CG: Control Group. EG: Experimental Group. *Mann Whitney U Test

4.3. Intragroup Comparison of Pre and Post-Measurements Findings

A paired Samples t Test for parametric variables were used and Wilcoxon test for nonparametric variables were used to examine for differences in regard to pre and post-test findings of intragroup variables.

4.3.1. Intragroup Comparison of Pre and Post- Measurements Findings for Viscoelastic Features (Frequency, Stiffness, Decrement, Creep, and Relaxation)

According to paired sample t-test results and Wilcoxon test, as a result of the statistical analysis, CG and EG demonstrated no statistical differences between pre and post-test findings of frequency, stiffness, and decrement ($p>0.05$) (Table 4.6).

The differences between pre and post-measurements for creep right and relaxation right were found statistically significant in CG and EG ($p<0.05$). These results showed that athletes in CG and EG demonstrated better creep and relaxation values for regardless of right side. There were no statistical differences between pre and post-test findings in the CG and EG for creep left and relaxation left values ($p>0.05$) (Table 4.7.).

It means that the athletes in CG and EG had an improvement in results of Mechanical Stress Relaxation Time [ms], Ratio of impairment and Relaxation time, characterising Creep (Deborah number) values.

Table 4.5. Intragroup Comparison of Pre and Post-Measurements Findings for Viscoelastic Features (Frequency, Stiffness, and Decrement)

			CG Mean ± SD	t/p	EG Mean ± SD	t/p
Frequency (Hz)	**Left**	**Pre**	18.03 ± 10.23	-0.894 0.385	26.46 ±5.26	0.334 0.743
		Post	31.77 ± 9.85		29.42 ±6.05	
	Right	**Pre**	18.03 ± 1.84	-1.631 0.124	25.50 ±4.53	-2.072 0.056
		Post	31.68 ± 9.34		28.75 ±4.89	
Stiffness (N/m)	**Left**	**Pre**	11.79 ± 1.96	-0.563 0.582	11.62 ±1.07	0.036 0.972
		Post	10.32 ± 2.04		11.01 ±1.12	
	Right	**Pre**	34.70 ± 63.82	-1.397 0.183	12.57 ±1.54	-1.873 0.081
		Post	11.29 ± 1.40		11.10 ±1.20	
Decrement (D)	**Left**	**Pre**	0.95 ± 0.13	-0.113 0.912	0.90 ± 0.10	1.631 0.124
		Post	0.95 ± 0.15		0.85 ± 0.10	
	Right	**Pre**	0.91 ± 0.07	-1.083 0.296	10.80 ±1.79	0.564 0.581
		Post	0.91± 0.75		0.86 ± 012	

Data expressed as mean ± standard deviation. CG: Control Group. EG: Experimental Group.

Table 4.6. Intragroup Comparison of Pre and Post-Measurements Findings for Viscoelastic Features (Creep and Relaxation)

			CG Mean ± SD	t/p	EG Mean ± SD	t/p
Creep (C)	**Left**	**Pre**	0.83 ± 0.10	-0.113 0.911	0.83 ± 0.11	-0.877 0.394
		Post	0.84 ± 0.13		0.85 ± 0.13	
	Right	**Pre**	0.88 ±0.10	-1.215* 0.224	0.90 ± 0.12	-2.276* **0.023**
		Post	0.85 ± 0.09		0.84 ± 0.10	
Relaxation (ms)	**Left**	**Pre**	13.74 ± 1.90	-0.491* 0.623	13.83 ± 2.20	-0.388* 0.698
		Post	13.77 ± 2.44		14.03 ± 2.52	
	Right	**Pre**	14.77 ± 2.11	-1.371* 0.170	15.05 ± 2.33	-2.102* **0.036**
		Post	14.13 ± 1.70		14.10 ± 1.98	

Data expressed as mean ± standard deviation. CG: Control Group. EG: Experimental Group *Wilcoxon Test $p<0.05$

4.4. Intergroup Comparison of Difference between Pre and Post-Measurements Findings

Intergroup Comparison of Difference between Pre and Post-Measurements Findings for Frequency, Stiffness, Decrement, Creep, and Relaxation

The Independent Samples test and Mann Whitney U test were used to compare the difference between pre and post measurements findings of frequency, stiffness, decrement, creep, and relaxation values. (Table 4.8)

There was no statistically significant difference between the control and experimental groups for pre and post-test findings of the frequency, stiffness, decrement, creep, and relaxation ($p>0.05$).

Table 4.7. Intergroup Comparison of Difference between Pre and Post- Measurements Findings for Frequency, Stiffness, Decrement, Creep, and Relaxation

Conditions (score)		CG Mean ± SD	EG Mean ± SD	T	p value
Δ Frequency (Hz)	Right	0.64 ± 1.57	0.61 ± 1.18	0.058	0.954
	Left	0.36 ± 1.61	-0.11 ± 1.37	0.897	0.377
Δ Stiffness (N/m)	Right	18.52 ± 53.04	22.37 ± 47.77	-0.216	0.831
	Left	4.26 ± 56.21	4.26 ± 56.21	-0.339*	0.734
Δ Decrement (D)	Right	0.02 ± 0.09	-0.01 ± 0.10	1.156	0.257
	Left	-0.02 ± 0.12	-0.02 ± 0.12	-0.697*	0.486
Δ Creep (C)	Right	-0.02 ± 0.08	-0.05 ± 0.08	0.996	0.327
	Left	0.00 ± 0.10	0.01 ± 0.06	-0.336	0.739
Δ Relaxation (ms)	Right	-0.63 ± 1.75	-0.92 ± 1.61	0.538	0.594
	Left	0.02 ± 2.02	0.19 ± 1.27	-0.285	0.778

Data expressed as mean ± standard deviation. CG: Control Group. Experimental Group. *Mann Whitney U test

5. DISCUSSION

The main goal of this study was to examine the immediate effects of spinal mobilization on upper trapezius muscle stiffness, tone, and elasticity in volleyball players. The volleyball players were randomly divided into two groups; the experimental and the control group. The control group received trapezius eccentric motor control exercises, the experimental group received trapezius eccentric motor control exercises with spinal mobilization application for C3-C4 segments. Overall, our hypothesis is not supported by data. In our study investigating the immediate effect of spinal mobilization on the viscoelastic features of the upper trapezius muscle in volleyball players. It was found that spinal mobilization did not have an immediate effect on the stiffness, tone and elasticity of the upper trapezius muscle. However spinal mobilization had an instant effect on creep and relaxation. The effects of the interventions on myotonometer features of the groups were found to be similar. The validity of the study findings is strengthened by both the randomization of the groups and the fewness of intergroup differences in our pre-measurement findings.

There is conflicting evidence for motor innervation of the trapezius muscle by the cervical nerves in the literature. Cervical fibers that were found to enter the trapezius muscle in 15 adult cadavers were examined. In addition to the innervation of the spinal accessory nerve, the researchers also described the cervical nerve innervation of all the trapezius muscles. C-2 to C-4 fibers were classified as Type I innervation, C-2 to C-3 fibers were classified as Type II innervation, and C-3 to C-4 fibers were classified as type II innervation (71). This information suggested that manual techniques to the C 2-3-4 spine levels as a result of any pain or pathology in the trapezius muscle may cause changes in the trapezius muscle. In this context, manual techniques were applied to the C3-4 level.

It is significant to evaluate any difference in upper trapezius muscle stiffness depending on the pathology and treatments we emphasized in our study. There are studies on this subject in the literature. The study of Liu, C. et al. was conducted to investigate the inter-tester reliability of the MyotonPRO tool in measuring the stiffness of the upper trapezius muscle and its ability to detect changes in stiffness during shoulder flexion movement among 20 men. The results showed excellent intra- and inter-test reliability for measuring upper trapezius stiffness with the shoulder in the neutral position, and also found a 14.2% increase in stiffness upon shoulder flexion between 0° and 60° flexion. Thus, the MyotonPRO tool could be considered as a valid method to measure changes in muscle stiffness. Also, being a very practical tool makes it a convenient method to measure upper trapezius stiffness (72). Therefore, we choose this device in our study to evaluate changes in upper trapezius muscle stiffness.

The study by Lee et al., which is very similar to our study, measured joint mobilization and therapeutic exercise applied to the cervical spine region and upper thoracic spine for functional deterioration among 18 people with chronic neck pain. In that study, the first group (n=9) had cervical and upper thoracic spine exercises and the second group (n=9), had joint mobilization together with the same exercise protocol. A pretest was performed and neck injury index, visual analog scale, active cervical range of motion, static balance capacity, and muscle tone were evaluated. The treatment was applied 60 minutes a day and 3 times a week for two weeks. Afterwards, the final test was performed with the same method. VAS, neck disability index, and active cervical ROM developed significantly in both groups. Group 2 improved significantly more in right lateral flexion and right rotation. Muscle tone in the upper trapezius improved significantly in both groups. For functional disorders caused by chronic neck pain, joint mobilization and therapeutic exercise have a significant effect on various types of functional impairment. Unlike our present study, in this study, there was a significant decrease in muscle tone after two weeks of application, 60 minutes a day for three times a week. For this reason, it was thought that a statistically significant value could be found if the long-term effects of spinal mobilization were investigated instead of immediate effects, as a limitation of our study (73).

According to the study in the literature, HVLAT manipulation treatment applied to the lumbar region (L2-L3-L4) did not cause a significant change in the tone, stiffness, and elasticity values of viscoelastic features of the rectus femoris muscle. In addition, there was no statistically significant difference between the measurement values obtained from the right leg and left leg rectus femoris muscles (74). Similar to our study, in this research manuel therapy applications did not cause any immediate effects on the viscoelastic features of the muscle.

The study of Ruiz-Sáez et al investigated the instant effects of a single cervical spine manipulation on the pressure pain threshold at the C3 to C4 vertebra level at latent myofascial trigger points in the upper trapezius muscle. Cervical spine manipulation was applied to C3 to C4 levels in the first group of the participants who were randomly divided into 2 groups. The other group underwent the sham manual procedure. The results show that cervical spine manipulation to the C3 to C4 segment causes significant increase in pressure pain threshold at latent trigger points in the upper trapezius muscle (75) Unlike our study, the immediate effects of manipulation provided a statistically significant difference in the pressure pain threshold of the upper trapezius muscle.

Malo-Urries et al. measured the instant impacts of upper cervical transonic spinal mobilization on cervical mobility and pressure pain threshold in people with cervicogenic headache. After administration, the mobilization group demonstrated significant increases in total cervical mobility and flexion-rotation test. There was no significant difference between the groups in terms of cervical pressure pain thresholds. However, there was a significantly lower headache intensity in the mobilized group. The mobilization intervention improved cervical range of motion and provided immediate headache relief in subjects with CEH (76). Similar to our study, spinal mobilization did not provide an instant effect on cervical pressure pain thresholds.

Past imaging studies on the lumbar spine showed that spinal mobilization with the PA technique applied to the spinous process increases the extension movement in the lumbar spine segment. There is not enough evidence in the literature about the cervical spine. In contrast, McGregor et al. discovered that the application of PA mobilization to the cervical spine would have a minimal beneficial effect if any intervertebral movement was present (77). In our study, PA mobilization was performed to provide intervertebral movement.

Park et al. aimed to compare and also analyze the biomechanical features of the upper cervical muscles on patients with cervicogenic headache to determine effective diagnostic and treatment methods. 20 healthy people and 20 people with headache participated in the study. The MyotonPRO device was used to measure the stiffness, tone, and elasticity of the subjects' suboccipital muscles and upper trapezius muscles. There was no important difference between the groups in the elasticity of the suboccipital muscles and the upper trapezius muscle. However, there was a statistically significant difference in tone and stiffness. This study showed that the tone and stiffness of the suboccipital muscles and upper trapezius were increased in subjects with headaches compared to healthy subjects (78). Unlike our study, we think that there was an increase in stiffness and tone, since this study was performed on people with cervicogenic headaches. This should be noted in future studies. The study shows that increasing upper trapezius muscle stiffness and tone may not be beneficial in individuals.

Kisilewicz et al. aimed to measure the impacts of compression trigger point therapy on trapezius muscle stiffness in professional basketball players. They also evaluated the reliability and validity of the MyotonPRO tool in the measurement of athletes (n=12). Stiffness assessments were taken just before and after a single period of trigger point compression therapy. This study demonstrated that a single period of compression trigger point therapy could be used to significantly reduce upper trapezius stiffness among professional basketball players (79). In contrast to this study, we did not have a significant effect on the stiffness of the trapezius muscle. As we applied a single session spinal mobilization, further long-term studies could be needed to understand the effects of manual therapy after a long period.

The study of Janecki et al., short (24-48 h) and long (2-3 weeks) term muscle tone was evaluated after an eccentric exercise program for the biceps brachi muscle. They found that the increase in muscle tone immediately after exercise is related to the rapid adaptation of the mechanical properties of the muscle. This rapid adaptation mechanism has been attributed to sarcoplasmal membrane damage and excessive calcium release. When the measurements were repeated 2-3 weeks later, it was found that the passive mechanical properties of the muscle changed in long term and as a result, the muscle tone increased. Muscle stiffness and tone can be affected by physical conditioning (80). Unlike our study, there were changes in muscle stiffness after the eccentric exercise program.

In a study similar to ours, Kawczyński et al. investigated the effect of eccentric exercise on trapezius muscle stiffness and spatial mapping of upper trapezius creep using a myotonometry tool. There were randomized 2 groups of 8 participants. Test-retest reliability of muscle creep and stiffness was measured. Muscle creep and stiffness were measured before, immediately after, and 24 hours after ECC when pain developed after exercise. The eccentric motor control exercise consisted of 50 eccentric contractions divided into 5 sets of 10 contractions at maximum power level. For sites of muscle contraction, trapezius muscle stiffness increased 24 hours after ECC, while decreased for muscle core immediately after ECC and 24 hours after ECC. Immediately after ECC and 24 hours later, trapezius muscle creep decreased for musculotendinous. For the first time, this study showed signs of inconsistency in the effects of ECC on muscle creep and stiffness, highlighting contrasting changes in muscle and muscle core viscoelastic features of the upper trapezius (81). Unlike our study, in this study, the effects of eccentric motor control exercise on muscle stiffness and creep were examined in the short and long terms. Therefore, longer-term studies can be planned for the future.

According to the study in the literature to investigate and find the presence and frequency of connecting branches between the spinal accessory nerve (SAN) and the second cervical (C2), third cervical (C3) and fourth cervical (C4) spinal nerve roots of the cervical plexus, three sections of the trapezius muscle were analyzed. During cadaver dissection, 18 (78%) branches were detected between SAN and C2, 11 (48%) between SAN and C3, and 12 (52%) between SAN and C4. A significant electroneurographic response was seen in all three segments of the trapezius muscle in all subjects (82).

In general, stiffness, tone and elasticity properties have been studied in the literature. What distinguishes our study from other studies and makes it strong, creep and relaxation values were examined and meaningful results were found. And also there are no studies in the adolescent population.

For adolescent volleyball players, the MyotonPro tool is a reliable and useful device that can be used in the clinic to measure the viscoelastic properties of the upper trapezius muscle.

The limitations of our study;

- Since the athletes did not accept participation for a long time during the season, the early effects were examined. This may be a limitation in terms of seeing the effects of manual therapy.
- Spinal mobilization is done lying down, according to Maitland. However, since the measurements and applications were made in the volleyball court, spinal

mobilization was also applied in the sitting position. It has been modified taking into account the circumstances.

6. CONCLUSION

This research investigated the immediate effect of spinal mobilization on the viscoelastic features of the upper trapezius muscle in volleyball players.

- Spinal mobilization application did not significantly contribute to the Stiffness, Tone and Elasticity values of the viscoelastic features of the upper trapezius muscle.
- Spinal mobilization application demostrated a significant improvement in the Creep and Relaxation values of the viscoelastic features of the upper trapezius muscle within the group.
- Spinal mobilization can be applied to improve Creep and Relaxation values. However, when compared with the control group, no significant contribution was observed, sufficient evidence was not found.
- Spinal mobilization may be good for Creep and Relaxation, but its long-term effects should also be considered.
- Considering the immediate effect of spinal mobilization, the effectiveness of treatment was not found to be significant. Longer-term effects can be looked at in future studies.

Additionally, these normative data can be useful to rehabilitation professionals when tracking the progress of volleyball players during therapy and guiding them in deciding whether a player can return to sport. Overall, these topics should be developed through further research in this field of study.

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8. APPENDIX

Appendix 1 Informed Written Consent

BİLGİLENDİRİLMİŞ EBEVEYN/AİLE OLUR FORMU

Yeditepe Üniversitesi, Sağlık Bilimleri Fakültesi, Fizyoterapi ve Rehabilitasyon Bölümü olarak voleybolcularda omurga mobilizasyonunun üst trapezius kas sertliği, tonusu ve esnekliği üzerine anlık etkilerini araştırmayı planlamaktayız.

Çalışmaya katılım gönüllülük esasına dayalıdır. Çocuğunuzun çalışmaya katılmasını isteyip istemediğinize karar vermeden önce araştırmanın neden ve ne için yapılacağını, çocuğunuzu bilgilerinin nasıl kullanacağını ve çalışmanın neleri içerdiğini anlamanız önemlidir. Lütfen aşağıdaki bilgileri okuyunuz. 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 okuduktan sonra araştırmaya katılmak isterseniz formu imzalayınız.

Çocuğunuzun araştırmaya davet edilmesinin nedeni; spinal mobilizasyonun trapezius kasının viskoelastik özellikleri üzerindeki etkisinin ortaya çıkarılmasının bu tedavinin etkinliğini artıracağını ve yaralanmayı önleme mekanizmasını açıklamaya yardımcı olacağını düşünmekteyiz. Araştırma, voleybolcularda omurga mobilizasyonunun üst trapez kasının sertliği, tonusu ve esnekliğiüzerine anllık etkilerini araştırmaktır. Çalışmada kontrol ve deney grubu olmak üzere iki grup olacaktır. Deney grubuna spinal mobilizasyon (C3-C4 segmenti) ve trapezius eksantrik motor kontrol egzersiziuygulanacaktır. Uygulama öncesi ve sonrası MyotonPro cihazı ile trapezius kasının sertliği, tonusu ve elastikiyeti ölçülecektir.Kontrol grubuna ise sadece trapezius eksantrik motor kontrol egzersizi uygulanacaktır. Aynı şekilde uygulama öncesi ve sonrası MyotonPro cihazı ile trapez kasının sertliği, tonusu ve elastikiyeti ölçülecektir.

Araştırmaya katılmayı kabul ederseniz, çocuğunuzun değerlendirmeleri Fzt. Hande Besna Göçen tarafından yapılacak ve bulgular kaydedilecektir. Araştırma kapsamında, çocuğunuza girişimsel olmayan değerlendirmeler ve ölçümler yapılacaktır. Çalışmaya katılmakla herhangi bir parasal yük altına girmeyeceksiniz ve ödeme yapılmayacaktır. Araştırmada yapılacak değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmada kullanılacaktır. Bu amaçların dışında kayıtlar kullanılmayacak ve başkalarına verilmeyecektir. Araştırma bir kongre ya da dergide yayın olarak kabul edilse de çocuğunuzun kimliğini ortaya çıkarabilecek kayıtlar gizli tutulacaktır.

Araştırmaya katılım tamamen isteğe bağlıdır, istediğiniz zaman herhangi bir ceza veya yaptırıma maruz kalmadan araştırmadan çekilebilirsiniz.

Çalışmaya dahil edilen tüm gönüllü sporcuların trapezius kası sertliği, tonusu ve elastikiyeti geçerlilik ve güvenilirliği literatürde kanıtlanmış olan MyotonPRO cihazı ile ölçülecektir.

Eksantrik motor kontrol egzersizi protokolü, %100 maksimum istemli kasılma (MVC) düzeyinde, 2 dakikalık bir dinlenme ile ayrılmış, 10 kasılmadan oluşan beş sette gerçekleştirilen 50 Eksantrik motor control kasılmasından oluşacaktır.

Spinal mobilizasyon trapezius kasının segmental innervasyonu olan C3- C4 spinal seviyeye uygulanacaktır. Bu seviyedeki eklemde oluşabilecek hipomobilite manuel terapi teknikleriyle giderilecek ya da azaltılacaktır.

Çalışma ile spinal mobilizasyonun voleybolcularda trapezius kasının viskoelastik özelliklerine etkisi araştırılacaktır.

SORUMLU ARAŞTIRMACILAR:
Dr. Ayça AKLAR ÇÖREKÇİ - Fzt. Hande Besna GÖÇEN

İLETİŞİM: Fizyoterapist Hande Besna GÖÇEN

‘’VOLEYBOLCULARDA OMURGA MOBİLİZASYONUNUN ÜST TRAPEZİUS KAS SERTLİĞİ, TONUSU VE ESNEKLİĞİ ÜZERİNE ANLIK ETKİLERİ’’ adlı bu çalışmaya velisi olduğum

…………………………………………………………………….

İsimli çocuğumun hiçbir baskı ve zorlama olmaksızın katılabileceğini beyan ederim.

Velinin:	Açıklamaları Yapan Kişinin :	Tanığın:
Adı, Soyadı:	Adı, Soyadı:	Adı, Soyadı:
Telefon:	Telefon:	Telefon:
İmza:	İmza:	İmza:
Tarih:	Tarih:	Tarih:

Apendix 2 Ethical Committee Approval

T.C.
MARMARA ÜNİVERSİTESİ
Sağlık Bilimleri Fakültesi
Girişimsel Olmayan Klinik Çalışmalar Etik Kurulu

PROJENİN ADI	: "Voleybolcularda Spinal Mobilizasyonunun Üst Trapezius Kas Sertliği, Tonusu Ve Esnekliği Üzerine Anlık Etkileri"
PROJENİN YÜRÜTÜCÜSÜ	: Dr. Öğr. Üyesi Ayça AKLAR ÇÖREKÇİ
PROJEDEKİ ARAŞTIRICILAR	: Hande Besna GÖÇEN
ONAY TARİHİ VE SAYISI	: 27.10.2021/96

Sayın: Dr. Öğr. Üyesi Ayça AKLAR ÇÖREKÇİ

"96" protokol numaralı "Voleybolcularda Spinal Mobilizasyonunun Üst Trapezius Kas Sertliği, Tonusu Ve Esnekliği Üzerine Anlık Etkileri" İsimli projeniz Fakültemiz Etik Kurulu tarafından incelenmiş oy birliği ile etik yönden uygun olduğuna karar verilmiştir.

Prof. Dr. Mehveş TARIM
Etik Kurul Başkanı

Prof. Dr. Ayşen GARGILI KELEŞ	Prof. Dr. Şule ECEVİT ALPAR	Prof. Dr. A. Nefise BAHÇECİK
Prof. Dr. Ş. Burak BEKAROĞLU	Prof. Dr. Zübeyir SARI	Prof. Dr. Hasibe KADIOĞLU
Doç. Dr. M. Emin ALŞAHİN	Doç. Dr. Aysel YILDIZ ÖZER	Doç. Dr. Ayşe KARAKOÇ
Dr. Öğr. Üyesi K. Burcu ÇALIK TÜMERDEM	Dr. Öğr. Üyesi Şule AKTAÇ	Dr. Öğr. Üyesi S. Kumral ÖZÇELİK
Dr. Öğr. Üyesi Fadime BİNGÖL		

EFQM EUA IPG
Marmara Üniversitesi Sağlık Bilimleri Fakültesi 34854 Başıbüyük/Maltepe İSTANBUL
0 (216) 399 62 42 (Faks)
0 (216) 777 57 86
Ayrıntılı bilgi için: Melek KARADAĞ AKYOL
sbfetikkurul@gmail.com
http://sbf.marmara.edu.tr

Appendix 3 Structured Questionnaire forPatient's Demographic Characteristics

1) Adı-Soyadı:

2) Telefon Numarası:

3) Age:

4) Cinsiyet:

- o Kadın
- o Erkek

5) Boy:

6) Kilo:

7) Meslek:

8) Dominant Taraf:

- o Sol
- o Sağ

9) Sigara/ alkol kullanıyor musunuz?:

10) Mevki:

11) Voleybola ne zaman başladınız?:

12) Daha önce cerrahi operasyon geçirdiniz mi?/ Geçirdiyseniz ne operasyonu?

……………………………………

13) Son 3 ay içerisinde herhangi bir sakatlanma yaşadınız mı? Yaşadıysanız nedir?

……………………………………

14) Omurganızda herhangi bir pataloji ya da deformite var mı?

……………………………………..

15) Antreman sıklığınız nedir?

- o Haftada 1 kez (1 time a week)
- o Haftada 2-3 kez (2-3 times a week)
- o Haftada 4-5 kez (4-5 times a week)
- o Her gün (Every day)

Appendix 4 Thesis Research Permits

T.C.
YEDİTEPE ÜNİVERSİTESİ REKTÖRLÜĞÜ
Sağlık Bilimleri Enstitüsü Müdürlüğü

Sayı : E.18897253-302.14.01-1005
Konu : Tez Araştırma İzni

YEDİTEPE ÜNİVERSİTESİ REKTÖRLÜĞÜNE

Enstitümüz Spor Fizyoterapisi Anabilim Dalı 20193055005-2D No'lu Yüksek Lisans öğrencisi Hande Besna GÖÇEN'in, Dr. Öğr. Üyesi Ayça AKLAR ÇÖREKÇİ danışmanlığında yürüttüğü "Voleybolcularda Omurga Metabolizasyonunun Üst Trapezius Kas Sertliği, Tonusu ve Esnekliği Üzerine Anlık Etkileri." konulu tez çalışmasını Eczacıbaşı Spor Kulübü'nde yapılabilmesi için gerekli izinlerin alınması hususunda gereğini bilgilerinize saygılarımla arz ederim.

Prof. Dr. Bayram YILMAZ
Müdür

Ek: PS02KAY_UNI_MUHNDLSK_FZK_FTKP_ODS_0877_001.pdf

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İnternet Adresi www.yeditepe.edu.tr
Kep Adresi : yeditepeuniversitesi@hs03.kep.tr
Bilgi İçin: Ufuk KILIÇASLAN
Telefon No:

ECZACIBAŞI SPOR KULÜBÜ

Yeditepe Üniversitesi, Sağlık Bilimleri Fakültesi, Fizyoterapi ve Rehabilitasyon Bölümü öğretim üyesi Dr. Öğr.Üyesi Ayça AKLAR ÇÖREKÇİ tarafından planlanan ve Yüksek Lisans öğrencisi Hande Besna GÖÇEN'in araştıracağı "Voleybolcularda Spinal Mobilizasyonunun Üst Trapezius Kas Sertliği, Tonusu ve Esnekliği Üzerine Anlık Etkileri" isimli çalışmanın ilgili kısımlarının kulübümüz bünyesinde gerçekleştirilebilmesi hususunda olumlu görüşlerinizi bildirmenizi arz/rica ederim.

18/10/2021

Sorumlu Araştırmacı

Dr. Öğr. Üyesi Ayça AKLAR ÇÖREKÇİ

İMZA

UYGUNDUR

18 / 10 / 2021

Cemal ERKSUN

(Kulüp Müdürü)

İMZA

Appendix 5 MyotonPro Device Data Collection Evaluation Form

Name Surname:

	Frequency (Tonus)	**Elasticity**	**Stiffness**	**Relaxation**	**Creep**
Egzersiz öncesi ölçüm (Sağ Trapez)					
Egzersiz sonrası ölçüm (Sağ Trapez)					

	Frequency (Tonus)	**Elasticity**	**Stiffness**	**Relaxation**	**Creep**
Egzersiz öncesi ölçüm (Sol Trapez)					
Egzersiz sonrası ölçüm (Sol Trapez)					

Appendix 6 Curriculum Vitae

Kişisel Bilgiler

Adı		**Soyadı**	
Doğum Yeri		**Doğum Tarihi**	
Uyruğu		**TC Kimlik No**	

Öğrenim Durumu

Derece	**Alan**	**Mezun Olduğu Kurumun Adı**	**Mezuniyet Yılı**
Doktora	-	-	-
Yüksek Lisans	-	-	-
Lisans	**Fizyoterapi ve Rehabilitasyon**	**Yeditepe Üniversitesi**	**2018**
Lise	-	**Dr. Kemal Naci Ekşi Anadolu Lisesi**	**2012**

Bildiği Yabancı Dilleri	**Yabancı Dil Sınav Notu**
İngilizce	**63.5**

İş Deneyimi (Sondan geçmişe doğru sıralayın)

Görevi	Kurum	Süre (Yıl - Yıl)
Lisansüstü Bursiyer	Yeditepe Üniversitesi	2019-2021
Fizyoterapist	Capella Sağlıklı Yaşam Merkezi	2018-2020

Bilgisayar Bilgisi

Program	Kullanma becerisi
Microsoft Office Program	İyi

Bilimsel Çalışmaları

Lisans Dönemi Tez Çalışması

Foam Roller'ınYeditepe Üniversitesi öğrencilerindeki ağrı, esneklik, eklem hareket açıklığı ve performansa akut etkisi. Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü. Lisans Tezi. İstanbul 2018.

Yüksek Lisans Dönemi Çalışmaları

The Attitudes of Undergraduate Physiotherapy and Rehabilitation Students towards Remote Education Process in Covid-19 Pandemic (WCPT Bildirisi)

COVID-19 pandemi süreci yaşlı astımlılarda alt ekstremite kas dayanıklılığı, fiziksel aktivite düzeyi, dispne seviyesi, düşme riski ve yaşam kalitesini etkiler mi? (4. Uluslararası Sağlık Bilimleri ve Yaşam Kongresi'nde sözel bildiri)

Appendix 7 MyotonPro Device Documents

Declaration of Conformity

Declaration number:	DC - 1101
Manufacturer:	MYOTON AS, Lõõtsa Str.8A, Tallinn 1415, Estonia
Product family name:	Myoton
Classification:	scientific instrument FOR RESEACH USE ONLY! monitoring device for non-vital physiological parameters (MD-1301)
Product description:	for non-invasive assessment of state of tension and bio-mechanical properties of superficial biological soft tissues eg. superficial skeletal muscles and tendons

Product Name	Product HS code
"MyotonPRO"	902480194099

Declaration

Myoton AS hereby declares that the device specified above conforms with the Essential Requirements of the Medical Device Directive - 93/42/EEC of June 14, 1993 as amended by Directive 2007/47/EC of 21st September 2007.

To ensure conformity with the provisions of the Directive applicable to the equipment, Myoton AS has designed and manufactured the device specified above in accordance with all major safety requirements concerning to CE mark Directive 93/68EEC, Low Voltage Directive 2006/95/EC and Electromagnetic Compatibility Directives 2004/108/EC, 92/31/EEC:

EN 60601-1-2, 2006 and 2007 – Medical Electrical Equipment Part 1-2
EN 55011, 2007+A2:2007 – Industrial, scientific and medical (ISM) radio frequency equipment
EN 61000, Part 3 and Part 4 – Electromagnetic compatibility (EMC)

Authorised by:

Aleko Peipsi – CEO
MYOTON AS
15th May 2014

Company name:
MYOTON AS
Reg.no.10533818,
VAT.no.EE100516818

Address:
Lõõtsa Str.8A
Tallinn 11415
Estonia

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Fax: +372 6098 254
contact@myoton.com
www.myoton.com