T.C.

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF SPORTS PHYSIOTHERAPY

THE EFFECTS OF NEUROMUSCULAR TRAINING ON ADOLESCENT MALE BASKETBALL PLAYERS

MASTER THESIS

DOĞUKAN TONGAR, PT.

İSTANBUL-2021

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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 2021/13-49.

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.

DOĞUKAN TONGAR
15.12.2021

DEDICATION

I would like to dedicate my thesis to my family and friends who are too many to write their names, and to my advisor Prof. Dr. Feryal SUBAŞI.

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First of all, I would like to express my gratitude and respect to my advisor, Feryal Subaşı, who helped me at every stage of my thesis.

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TABLE OF CONTENTS

LIST OF TABLES AND GRAPHS

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

YBT: Y-Balance Test

MCET: McGill Core Endurance Test

VJT: Vertical Jump Test

EG: Exercise Group

CG: Control Group

ACL: Anterior Cruciate Ligament

NMT: Neuromuscular Training

PS: Power and Sample Size Calculation

NMTG: Neuromuscular Training Group

SEBT: Star Excursion Balance Test

CMJ: Counter Movement Jump

DJ: Drop Jump

ABSTRACT

Tongar, D. (2021). The Effects of Neuromuscular Exercise Program on Adolescent Male Basketball Players, Yeditepe University, Institute of Health Sciences, Department of Sports Physiotherapy, Master's Thesis. Istanbul

The purpose of this study is to compare the effects of a neuromuscular exercise program on balance, vertical jump and core endurance. Sixteen basketball players in Dostlukspor Club are included in the study. Participants were assigned to either the Exercise Group (EG) or the Control Group (CG) by simple computer-based randomization. While EG participated to the neuromuscular exercise program as a warm up program, CG continued conventional warm up program twice a week for six weeks under the supervision of a physiotherapist. The neuromuscular exercise program including balance, mobility, plyometrics and core stabilization exercises lasted for 20-25 minutes. Assessments included Y-Balance Test (YBT), McGill Core Endurance Test (MCET) and Vertical Jump Test (VJT) for measuring balance, core endurance and vertical jump respectively. All the participants were evaluated before and after interventions. Study showed that there was a significant difference in all reach directions of YBT in EG before and after interventions ($p<0.05$). Moreover, a significant difference was found in all directions except the right anterior direction comparing EG and CG ($p<0.05$). A significant difference was found in the core endurance parameter including endurance of the flexor, extensor and right/left core regions in the basketvball players of EG at the end of 6 weeks ($p<0.05$). In the CG, a significant difference was found only in the endurance of the extensor region at the end of 6 weeks ($p<0.05$). In the comparison between the groups, it was found that the applied neuromuscular exercise program was influential on the core endurance parameter of the flexor, extensor and right/left core regions ($p<0.05$). At the end of 6 weeks, no significant difference was found in the vertical jump parameter in the both groups when compared intragroup and intergroup differences ($p>0.05$). In summary, the study concluded that NM warm up traning positively affected core endure and dynamic balance compared to traditional warm up program in the adolescent basketball players. Thus, NM exercise program performed during warm up period may encoureged among adolescnet basketball players to improve perfomance parametrs.

Keywords:Neuromuscular warm-up, Y Balance, Core Endurance, Vertical Jump

ÖZET

Tongar, D. (2021). Nöromuskuler Egzersiz Programının Adölesan Dönem Erkek Basketbol Oyuncuları Üzerine Etkileri, Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Spor Fizyoterapisi Anabilim Dalı, Yüksek Lisans Tezi. İstanbul

Bu çalışmanın amacı, nöromüsküler egzersiz programının denge, dikey sıçrama ve core dayanıklılık üzerindeki etkilerini karşılaştırmaktır. Çalışmaya Dostlukspor Kulübü'ndeki 16 basketbolcu dahil edilmiştir. Katılımcılar basit bilgisayar tabanlı randomizasyon ile Egzersiz Grubuna (EG) ya da Kontrol Grubuna (KG) atanmıştır. EG, nöromüsküler egzersiz programına ısınma programı olarak katılırken, KG, altı hafta boyunca haftada iki kez geleneksel antrenman ve ısınma programına devam etti. Denge, mobilite, pilyometrik ve core stabilizasyon egzersizlerini içeren nöromüsküler egzersiz programı 20-25 dakika sürdü. Değerlendirmeler sırasıyla denge, core endurans ve dikey sıçramayı ölçmek için Y-Denge Testi (YBT), McGill Core EnduransTesti (MCET) ve Dikey Sıçrama Testi'ni (VJT) içeriyordu. Tüm katılımcılar egzersiz programına başlamadan önce ve egzersiz programı tamamlandıktan sonra değerlendirildi. Çalışma, program uygulanmadan önce ve sonra EG'de YBT'nin tüm uzanım yönlerinde anlamlı bir fark olduğunu gösterdi ($p<0.05$). Ayrıca EG ve CG karşılaştırıldığında sağ ön yön hariç tüm yönlerde anlamlı fark bulundu ($p<0.05$). EG basketbolcularında fleksör, ekstansör ve sağ/sol kor bölgelerinin dayanıklılığını içeren kor dayanıklılık parametresinde 6 hafta sonunda anlamlı farklılık bulundu ($p<0.05$). KG'de ise 6 hafta sonunda sadece ekstansör bölgenin enduransında anlamlı fark bulundu ($p<0.05$). Gruplar arası karşılaştırmada uygulanan nöromüsküler egzersiz programının fleksör, ekstansör ve sağ/sol kor bölgelerinin kor dayanıklılık parametresi üzerinde etkili olduğu bulundu ($p<0.05$). 6 hafta sonunda grup içi ve gruplar arası farklılıklar karşılaştırıldığında her iki grupta dikey sıçrama parametresinde anlamlı bir fark bulunmadı ($p>0.05$). Özetle, çalışma, adölesan basketbolcularda geleneksel ısınma programına kıyasla NM ısınma programının core dayanıklılık ve dinamik dengeyi olumlu etkilediğini ortaya koymuştur. Bu nedenle, ısınma döneminde yapılan NM egzersiz programı, performans parametrelerinin iyileştirilmesi için adolesan basketbolcular için teşvik edilebilir

Anahtar Kelimeler: Nöromuskuler Isınma, Y Denge, Dikey Sıçrama, Core Endurans

1. INTRODUCTION AND PURPOSE

Basketball is one of the most popular sports in the world. Worldwide 450 million registered players are estimated (1). Basketball is not strictly defined as a contact sport. However, the lower extremity joints are under severe stress (2). There are different types of activity and movement patterns in basketball. Fast sprints, shooting, shifts, and jumpings. One of these movements is performed in the game every 2 seconds. In the study, it was revealed that an average of 105 high-intensity runnings was done in a match (3).

With the increasing number of players playing, there is an increase in the lower extremities' injury rate. In a 17-season study conducted in the NBA, 62% of orthopaedic injuries involve the lower extremities . The most common of these injuries are the ankle (14.7%), followed by the knee and spine (4).

The number of studies revealing injury risk factors in basketball is relatively high. In prospective studies, past injuries, anatomical factors, biomechanical alignment, poor balance and lack of muscle flexibility are identified as risk factors for injury in basketball (5,6). In order to prepare effective preventive training program these risk factors must be considered and exercise choices should be added according to focusing on these parameters while designin the programs.

The involving of risk factors, various strategies have been recommended for injury prevention programs. Preventive programs can be designed as sport-specific. A well-designed preventive warm-up program can lead to improvements in performance parameters but not increase fatigue. The well designed warm-up program can cause; increased body and muscle temperature, increased oxygen consumption, increased blood flow to muscles, oxygen supply to muscles, improved anaerobic metabolism, increased nerve conduction velocity (7).

Besides other risk factors, neuromuscular control of the lower extremity is associated with knee and ankle injuries. Neuromuscular control is defined as the body's ability to keep the center of gravity at one point. Furthermore it is seen as the most modifiable risk factor for preventing injuries (6).

In the literature, it has been shown that neuromuscular warming programs reduce lower extremity injuries in many sports (8–10). According to a meta-analysis study conducted in 2015, the neuromuscular warm-up program was also effective in reducing the injury rate in basketball players (11). The neuromuscular warm-up program includes plyometrics, strengthening, balance and stabilization exercises that increase the lower extremity's alignment when landing from a jump, increasing muscle recruitment patterns and balance (12). At the same time, the fact that no equipment is required provides easy integration and makes it cost-effective.

Although a neuromuscular warm-up program is to develop to prevent injuries, studies investigating the program's effects on athlete performance parameters related to sport-specific skills such as dynamic balance, explosive power, neuromuscular adaptation, etc., have been limited in the literature. Studies are showing positive effects on sprint, jump height and balance (13,14) .

Therefore, the purpose of the study is to investigate the changes in dynamic balance, vertical jump, and trunk endurance parameters in male adolescent athletes included in the bodyweight neuromuscular program in addition to regular training programs. The experimental group will receive a bodyweight neuromuscular program twice a week as a pretraining warm-up program, while the control group will continue with the traditional warm-up program. Our hypothesis is; there will be a significant improvement in the dynamic balance, vertical jump and trunk endurance parameters in the experimental group compared to the control group.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Basketball

Basketball was started to be played in America in 1891 by James Naismith for seven people and three periods of 20 minutes. It was played in Paris in 1893 for the first time in Europe and was included as a sport in the Berlin Olympics in 1936.

An official basketball match consists of 2 teams (10-12 players), and one team can keep up to 5 players on the field at the time of the game. The main goal is to get the ball into the opponent's basket. The Crucible length is 3.05 meters. After a successful score, the ball passes to the opponent, and there is an attacking defence loop. There are 4v4, 3v3, 2v2 and 1v1 variations of basketball. Game time varies depending on the level of competition. Professional and international games are played in 10-12 minutes x 4 quarters. The halftime is 15 minutes, and there is a 2-minute break between each quarter. Although the average time is 40-48 minutes, it can take up to 2 hours with pauses (3). The pauses can occur for many reasons;

1) A team's coach can take a 60-second timeout. (Strategic)

2) There may be a foul in the game. Fouls can be either offensive or defensive.

A defensive foul occurs when the defender performs actions such as blocking, pushing, hitting. An offensive foul occurs with the movements of charge with the ball. A player has a maximum of 5 fouls. The substitution can occur anytime the game is stopped, and there is no restriction. This makes basketball a tactical and strategic game..

Basketball players are divided into 3 positions, these are; guard, forward and the center (15). At the same time, basketball players are divided into subgroups numerically;

1) Point guard

2) Shooter guard

3) Forward

4) Power forward

5) Center.

2.1.1 Technical Movements in Basketball

2.1.1.1 Pass

In basketball, passing is one of the most basic movements and is the second most used technique in the game after shooting (16). When attacking, the players must pass cooperatively to control the ball and the shot opportunity. Teams with more assists win more matches (If a pass is made and a score is made, it is called an assist) (17). In basketball; There are four types of passing: chest pass, bounce pass, baseball pass, and double hand pass. Small steps are made during the pass, and the body stretches forward while removing the ball from the arms and fingers. Lower extremity mobility and trunk stabilization during passing are essential for the success of the pass.

2.1.1.2 Rebound

If the ball bounces after a non-scoring shot, retrieving the ball is called a rebound. It is also essential in attack and defence. Rebounding on an attack allows the ball to be used again and gives a team a chance to re-attack. The player predicts where the ball will bounce, takes position accordingly and needs high explosive force. In the rebound moment, good posture, support surface, and rapid jumping are essential. There are 4 Phases of rebound movement; charging phase, boost phase, flight phase and landing phase (18) .

2.1.1.3 Dribbling

Dribbling is an essential skill for game success in basketball. With the ball, the player travels the distance, taking control of the ball. In dribbling, the player's visual-spatial perception must be excellent. In the game, slow steps and dribbling are used to reduce the speed, while fast dribbling is used to accelerate the game. The purpose of dribbling; Going over the opposing team's defence by attacking and scoring can be avoiding the opponent's pressure or the 8-second rule. If the opposing team player is defending in close range, a low dribble is used to avoid stealing. The ball is dribbled, keeping it as close as possible and below the waist. When there is a one-on-one or a fast break chance with the opponent, fast dribbling is done by keeping the body higher. During

the intense defence, the lower extremity is actively used to change the direction, and the ball continues to be driven with the other hand (reverse). Alternatively, when the pressure increases, it can be taken to relax the game by retreating.

2.1.1.4 Shooting

To score in basketball, the ball must pass through the hoop. In order to score, a booming shot must be taken. Factors affecting a shot; the angle of the ball, its height and the speed at which it is released. Air resistance has very, very little effect on the speed of the ball. The shooting mechanics generally do not depend on the player's position. If a shot is taken close to the basket, it is taken slowly; if a far shot is taken, it is shot quickly. When shooting, the position is taken as follows; The knees are flexed slightly, the bodyweight is evenly distributed to the lower extremities, and the ball is released from the hand at a certain speed with the coordination of the lower and upper extremities. (19).

2.2 Basketball Sport Biomechanics

2.2.1 Lower Extremity Biomechanics in Basketball

Biomechanics is the mechanical study of the motions of a biological system. It has been reported that biomechanical knowledge can improve performance levels and reduce injury rates for coaches and clinicians (20).

Basketball is a multi-directional game, and the use of the lower extremities is essential (21). During basketball movement, the lower extremity allows the player to locomotion and take the proper position at the right time. Movements in basketball can occur horizontally and vertically. A good jump, cutting and improve the basketball player’s performance. Because the loads required by these movements are too high, the player may also be at risk for injury. Understanding lower extremity biomechanics (loading, joint angles and forces) can determine whether the player is at risk for injury (20). Biomechanical training given with the neuromuscular warm-up program can affect the rates of lower extremity injuries and make it safer to return to sports.

2.2.2 Upper Extremity Biomechanics in Basketball

While the lower extremity provides explosive movements and positioning for the basketball player, the upper extremity region is the main contact with the ball. The upper extremity is actively used repeatedly in rebounding, dribbling, creating space with the ball, shooting and passing the ball. Its use in many movements makes it difficult to focus on training on upper extremity biomechanics, and in the literature it has been showed in the literature that studies on upper extremity biomechanics are less than lower extremity (22).

The upper extremity is constantly actively used in basketball. It has been reported that basketball players perform more than 200 overhead (>90degree of shoulder flexion) activities in a match (23).

In basketball players, reasonable upper extremity control, agility, and stability are recommended to avoid injuries against non-contact and high contact forces.(22).

2.3 Injuries In Basketball

Basketball is one of the most popular sports in the world. In a study conducted in 2006, it was found that 556 thousand men and 456 thousand women played basketball at the high school level in the United States (24). Although it provides health benefits, basketball is both a physical and mental sport in terms of self-confidence, weight control and strength increase, but despite these benefits, it carries the risk of injury. In a competitive basketball environment, there are 7.1 injuries per 1000 hours for boys and 7.9 injuries per 1000 hours for girls. Basketball injuries lead to physical and moral losses such as playing time and doctor and hospital fees (25).

Studies show that injury rates vary with gender (26). Understanding the epidemiology in athlete injuries constitutes the first step of programs planned to reduce injury rates.

Injury should include three criteria by definition;

1) Participation in a basketball training or game

2) Must need a medical support

3) Making the athlete unable to participate in sports for one or more days..

Between 2005 and 2007, there was a 1.94 injury rate per 1000 hours in high school level basketball. In addition, injuries in the match environment were seen more than those in the training environment (24).

2.3.1 Characteristics of Basketball Injuries

In basketball, 83% of the injuries are seen as repetitive injuries. Generally, the distribution of injuries on body parts is the foot / ankle (39.7%), knee (14.7%), head / face / neck (13%), arm / hand (9.6%) and thigh / hip / upper leg (8.4%). The most common injury types are ligament sprains (44.0%), muscle / tendon strains (17.7%), contusions (8.6%), fractures (8.5%) and concussions (7%), respectively (24).

More than half of the injuries keep players from playing for less than a week (51.3%). 1-three weeks (30%), more than 3 weeks (8.1%). Specifically, 8.5% of injuries cause athletes to close the season and 7.5% require surgery. Most fractures (21%), muscle / tendon strains (7.9%) and ligament sprains (6.7%) require surgery (24).

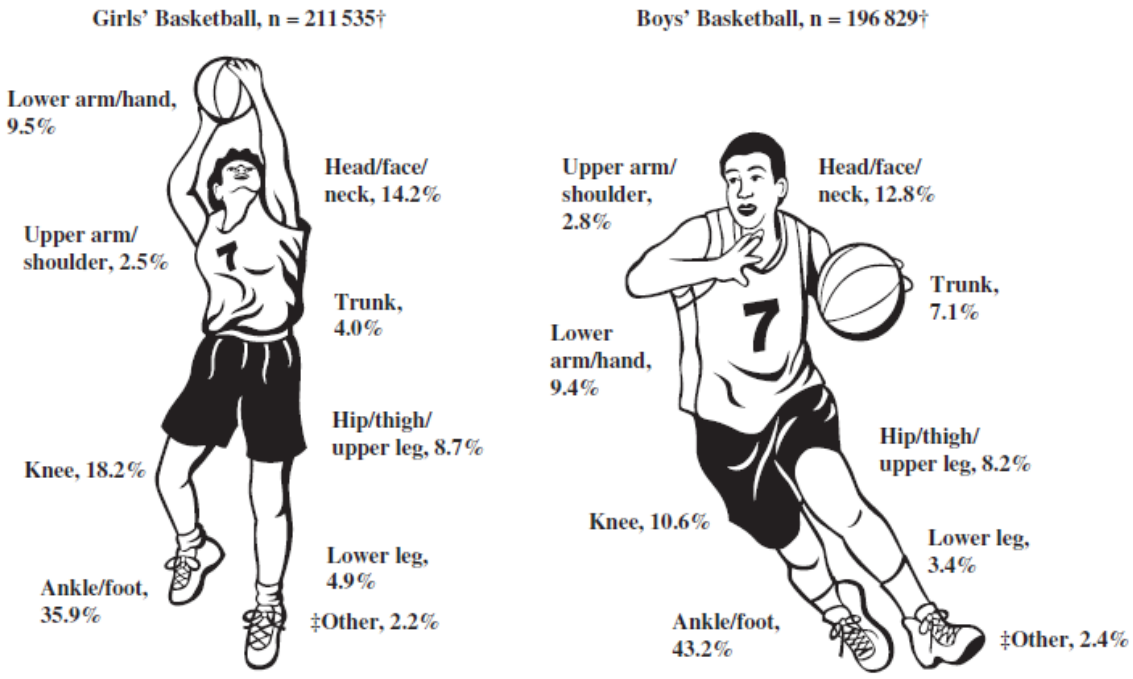

Figure 2.1. Body sites injured in high school girls' and boys' basketball (24).

2.3.2 Injury Mechanisms

In boys' basketball, the injury rate of the players playing in the guard position is the highest (45.9%). Depending on the positions, the most common form of injury is ligament sprains. Also, the more aggressive playstyle of male players may make them more susceptible to concussion injuries (27). Movements that cause the most injuries in basketball; Rebound (25.1%), defending (14.8%), overall game (16.9%), dribbling (8.9%) and shooting (8.5%). The mechanisms of injury are collision with another player, jumping/landing, inversion of the foot in plantar flexion etc (24). Explaining sport-specific injury mechanisms will make it easier for coaches, physiotherapists and researchers to organize preventive programs. Rebound and jumping/landing cause the majority of ligament injuries. In the literature, it has been shown that jumping and balance training has a protective effect from injuries(10,28).

2.3.3 Injury Risk Factors

Worldwide, $ 1 billion is spent on sports injuries annually, and the economic importance of injury prevention programs can be understood from this information. Bahr and Krosshaug reported 3-5 million annual injuries in the United States alone in their study(29). With these severe numbers in the literature, researchers and clinicians started to organize preventive programs. However, for these studies to reach results, it was necessary to reveal the risk factors. Many risk factors, including intrinsic and extrinsic, were presented in the studies..

Extrinsic Risk Factors ;

- Competition Level
- Skill Level
- Shoes Type
- Tape Usage
- Playing Surface

Intrinsic Risk Factors;

- Age
- Gender
- Injury History
- Inadequate Rehabilitation
- Aerobic Fitness
- Body size
- Dominant Side
- Flexibility
- Muscular strength
- Reaction Time
- Postural Stabilization
- Anatomical Arrangement
- Foot morphologies (30)

2.3.4 Injury Prevention in Basketball

There are excessive acceleration, deceleration and cutting manoeuvres in basketball, which is a non-contact sport. These manoeuvres may put the player at risk for injury. In order to reduce these injury rates, it is recommended to integrate preventive programs into the players' routine (31).

Many neuromuscular protective programs have been designed for athletes in the literature, and many of them show positive effects. The most significant factor in these programs not being able to participate in the regular training routine is time constraints.

FIFA 11+ is the most popular one among the injury prevention programs and the one whose effect has been proven in the literature (32). This program, which was developed for football players, is effective in other sports, including cutting, changing direction, jumping, acceleration, and deceleration. There is a study showing that it is protective from injuries in male adult basketball players (33).

Preventive programs can be specific to body areas. In basketball, where ankle injuries are standard, programs to improve balance/proprioception and external support equipment

are also used. A study showed that a 20-minute program performed once a week reduced ankle sprains by 35% (34).

Separate protective programs have .been organized for injuries that can end a career. An ACL injury can be career-ending for basketball players. Neuromuscular programs developed to protect against ACL injuries in basketball are generally aimed at improving lending strategies. However, it is seen that these programs are not as effective in basketball as they are in football players. On top of that, in a prospective study lasting 12 years, the participants applied the program for 20 minutes, three times a week, within the ACL injury prevention program developed for female basketball players. The program aimed to increase hip joint function, improve balance, strengthen hip muscles and improve jumping/landing strategies, and this program has been shown to reduce ACL injuries significantly (35).

It is suggested in the literature that young athletes should also benefit from injury prevention programs. In a study, it was shown that neuromuscular programs reduce lower extremity injury rates (36).

2.4 Neuromuscular Training Program

Programs that target neuromuscular control are called NMT programs. Neuromuscular Training Programs (NMT) have been found to reduce the risk of lower extremity injury in many sports (8–10). Additionally, Hübscher et al. showed that NMT reduces injuries in their systematic review (37). NMT is designed to increase joint position sense, increase joint stabilization and protect the lower extremity (12). Programs targeting neuromuscular control are known to increase dynamic balance, improve muscle contraction patterns, and increase postural stabilization and balance. These gains are provided by the plyometric, endurance, agility, strength and stability exercises included in the program (6). Most injury prevention programs include a ball or therabands etc. It is not accessible to every club and athlete as it requires equipment. NMT programs, on the other hand, are more accessible and easy to implement since no additional equipment

is needed. There are five programs called the NMT program in the literature; FIFA 11+, KIPP, HarmoKnee, AKPPTP and PEP.

2.4.1 Neuromuscular Control

Neuromuscular control; is the body's ability to keep its center of gravity on the base of support. It is categorized as static and dynamic balance and is the most modifiable risk factor while avoiding injury (6,38).

The most crucial component in NMT programs targeting neuromuscular control is body weight. Neuromuscular control can be increased by adding core stabilization and plyometric exercises.

2.4.2 Core Stabilization

Core stabilization; is the ability of the body to maintain the position of the body against external and internal forces (38). Zazulak et al. revealed that the lack of core control leaves the trunk uncontrolled during movement, which forces the lower extremity to be valgus, increases the knee abduction moment and causes knee ligament injuries (39). In order to reduce the risks of these injuries and increase joint awareness, therapists add plyometrics and core stabilization exercises to their pre-season and in-season programs (40).

2.4.3 Plyometrics

Performance in basketball, which is a high-intensity sport, depends on aerobic and anaerobic capacity (41). Thanks to the power and speed studied in the trainings, speed changes, jumps and changes in direction are realized in the game.

Plyometric training prepares the players for the activities in the game and is also included in the rehabilitation programs. Plyometric exercises are performed with concentric contractions immediately following a sudden eccentric movement. The aim is to release maximum force in minimum time. This cycle of the muscle is called the stretch-shortening cycle and is used in activities such as acceleration, change of direction, vertical jump in the basketball game (42).

In a meta-analysis study by Markovic et al., plyometric training has a significant effect on vertical jump (43).

2.4.4 Balance

Balance is the ability of the body to maintain the center of gravity with rapid and continuous information coming from the visual, vestibular and somatosensorial systems. A good balance ensures that basketball players are protected from injuries during the game. Static balance is the body's ability to protect the base of support during minimal movement. Dynamic balance is the body's maintaining or regaining its base of support during activity—exercises aimed at improving balance focus on improving body control and motor skills (44). Balance is essential in many sports today. Balance plays a vital role in physical contact, dribbling, rebounding, jumping and changing direction during basketball. All of these activities take place in a minimal space in a minimal time (45). The relationship between balance and injury rate is clearly stated in the literature. Studies show that balance exercises reduce the risk of injury(37,46).

2.5 Activities in Basketball

Basketball is a sport that includes low, moderate and high-intensity activities (47). According to their purpose, these activities differ in terms of structure, intensity, distance, frequency, and duration (48). Multidirectional runs, shuffles, jumps occur almost every minute more than other sports (49).

2.5.1 Distance Covered

The distance covered in the basketball game is important when preparing a preventive program for the trainers and the staff interested in performance (1).In addition to the total distance covered, how much distance is covered with which activity should also be known (48).

Although it varies according to the level of competition, an average distance between 4.40 km and 7.56 km is covered in a basketball game (48). In addition, some studies say the average is 5-6 km in a 40-minute game. Considering the distance covered per minute, basketball players cover a distance of 130m/min (48). Since each position has different

requirements, activities in basketball are specific according to the position. A player playing in the guard position (6635m) travels more distance than a player playing in the forward position (6016m) and center (5225). Although we have limited information in the literature, basketball coaches and performance staff should pay attention to the activity distribution and distance covered while preparing preventive programs (48).

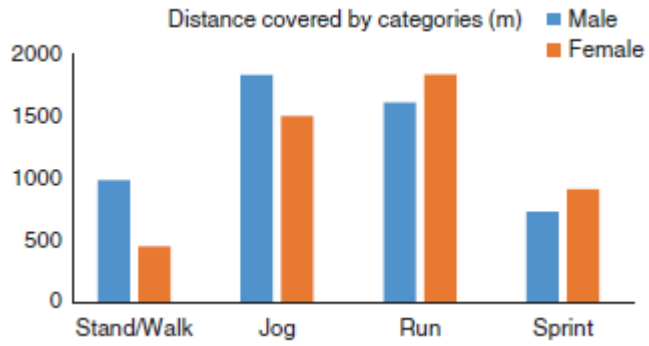

Figure 2.2 Distance coverage for male and female basketball players (48).

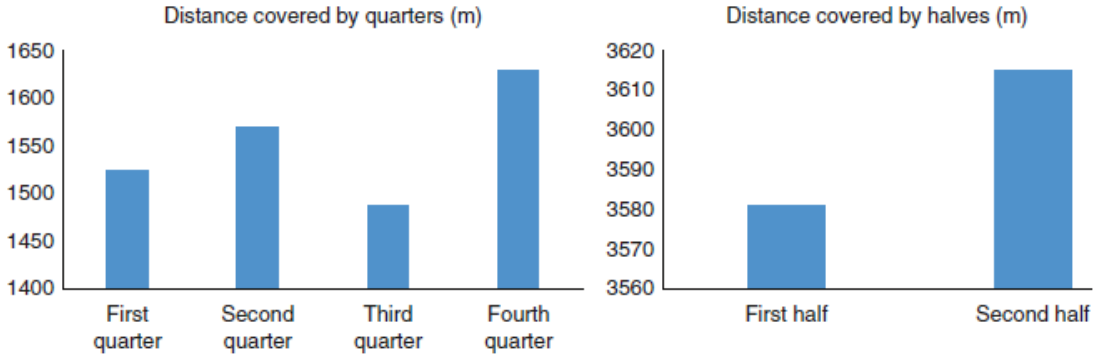

Figure 2.3 Distanve coverage by quarters and halves (48).

2.5.2 Activity Frequency

The activity frequency helps us to create the activity profiles of the players during the match. In line with this information, while the protective program is being prepared, programs close to an accurate match can be prepared. On average, basketball players change activity every 1-3 seconds. The activity frequency per minute is 21-57 movements/min (48). The position played affects the frequency of activity. In the literature, it is shown that backcourt players perform more activities than other players. Primarily the dribbling numbers (66 vs 21) were found to be higher than the frontcourt

players (23). A study showed that more high-intensity activities occur at high game levels than at moderate levels (like sprints and shuffles) (23). It is known that there is a difference in activity frequency between male and female players due to the difference in physical and fitness characteristics (1). While 758-2749 activities were performed per game for male players, this number was found to be 576-1764 for female players (48).

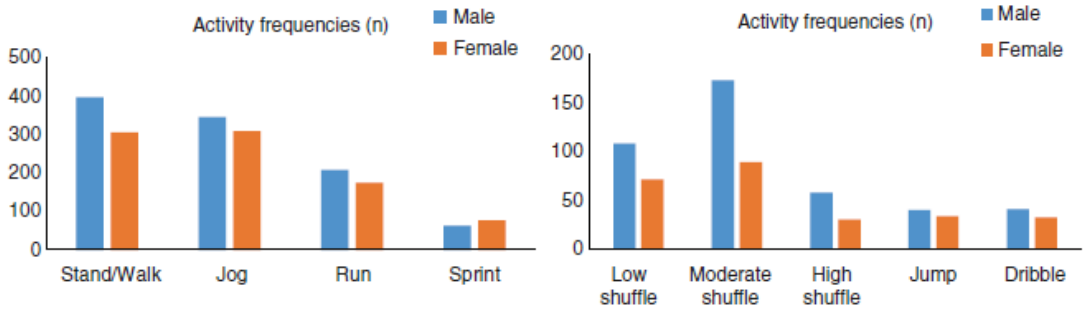

Figure 2.4 Activity Frequencies Male vs. Female (48).

2.5.3 Activity Duration

In the game of basketball, players do different activities in different parts of the game. In a study, the distribution of activities during the game is shown as follows (48).;

-23-66 % standing/walking

-5-33% running

-6-36% jogging

-0-9% sprinting

-2-15% low intensity shuffling

-0-9% high intensity shuffling

-1-11% dribbling

-1-2% jumping

Physical characteristics such as height and weight or aerobic capacity of the players may differ in the distribution of these activities (50).

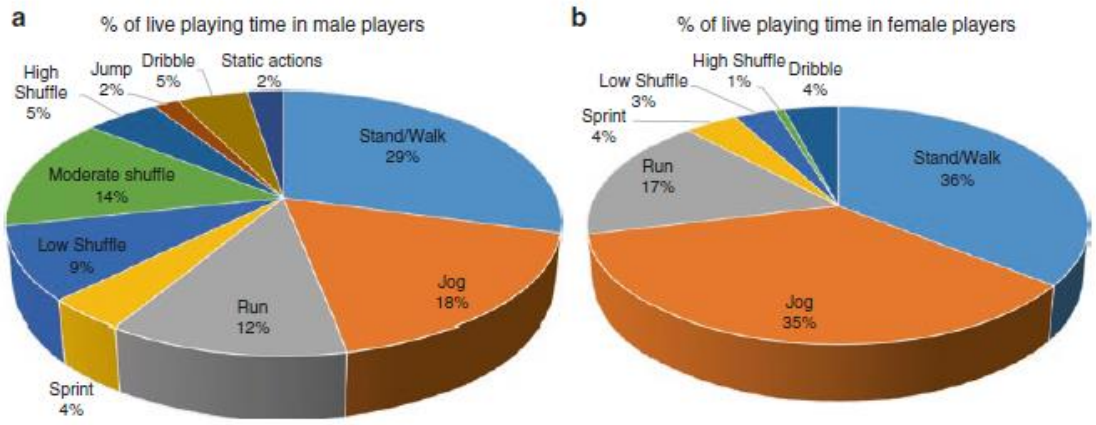

Figure 2.5 Activities in game for male and female players (48).

3.MATERIAL AND METHOD

3.1. SUBJECTS

The research sample consists of the 15-18 age group of the Dostluk Sports Club, which has an adolescent age group that can train regularly in its basketball court in Istanbul under pandemic conditions.

Sixteen male adolescent basketball players participated in our study. The study was applied to amateur basketball players during the inter-season period. As a randomization method, the participants were allocated to the NMT group or the control groups using the simple randomization method with a computer-based program (www.randomizer.org).

3.1.1. Inclusion Criteria

• Parental consent to voluntarily participate in the study

• Being a 15-18 age group basketball player.

• Attending two training sessions in a week

• No lower extremity injury in the last 6 months

3.1.2. Exclusion Criteria

• Missing 2 or more workouts
• Injury during the study
• Switching to another team during study
• Not participating in the pre- and post-assessment tests

The study protocol was approved by the Yeditepe University Non-Invasive Clinical Research Ethics Committee at 3.07.2021, and the issue number was 202105033 (Appendix 2). Participants were involved in the study voluntarily. The aim and plan was explained, and informed written consent was obtained from each patient (Appendix 1).

3.1.3. Flow of Research

Participants were included in the study voluntarily. Informed parent consent form/informed, voluntary consent form was obtained in writing from each participant, the purpose and plan of the study were explained. The study was applied to amateur basketball players during the inter-season period. As a randomization method, the participants were allocated to the NMT group or the control groups using the simple randomization method with a computer-based program (www.randomizer.org). To the first group; Neuromuscular Warming program training will be given before the study and applied twice a week for six weeks. An evaluation was made at the beginning of the study, and a final evaluation was made at the end of 6 weeks.

The second group; continued the traditional education program. Pre- and post-training assessments were applied to this group in the same way. None of the players participating

in the study was excluded from the study for any reason. (Figure 1. Flowchart Diagram)

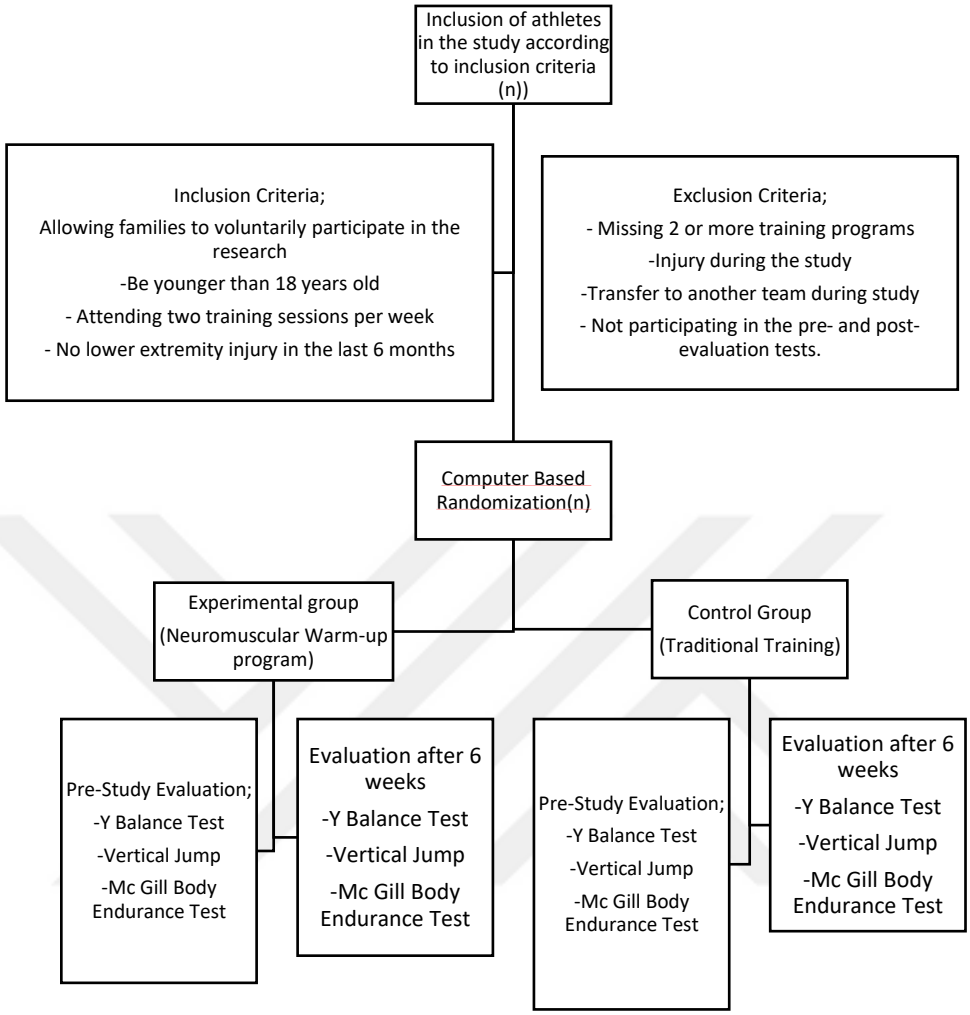

Figure 3. 1Flowchart Diagram

3.1.4. Study Protocol

The athletes were divided into two groups: the control and experimental groups (8 participants in the control group, 8 participants in the experimental group). The computer-based randomization method as randomization method was performed before the exercise training. All participants performed their assessments and exercises under the supervision of a physiotherapist and basketball coach. This study was planned to be two times a week for six weeks. After the evaluations, all the exercises were taught to the experimental group by the physiotherapist. While the experimental group applied for this program and the traditional training, the control group continued the traditional training program.

Since all the exercises were done with body weight, no extra equipment was needed.

Table 3.1. Neuromuscular Exercises of Experimental Group

Exercise	Repetition
Jog line to line	4 basketball court
Shuttle Run	4 basketball court
Lateral and Backward Running	4 basketball court
Leg Swing front to back site to side	1/2 x 12
Lateral Squats	1/2 x 12
Lunge superior reach	1 basketball court
Walking quad stretch	1 basketball court
Monster walks	1 basketball court
Inverted hamstring stretch	1 basketball court
Lateral Crossover step	1 basketball court
Multidirectional lunges	2/3 x 10
Nordic Hamstrings	2/3 x 5
Single Toe Raises	2/3 x 12
Lateral bridge	2/3 x 30 seconds
Vertical jumps	1/2 x 12
Lateral hops	2/3 x 20
Single legged hops	2/3 x 10
Forward hops	2/3 x 10

Jog Line to Line

Participants jog at a light pace, going back and forth across a basketball court four times.

Shuttle Run

Participants jog at a slow pace according to the field lines.

Lateral and Backward Running

Participants perform runs in the lateral direction and in the back direction.

Leg Swing Front to Back Side to Side

Participants dynamically swing their lower extremities anterior/backward and laterally/medially.

Lateral Squats

In this movement, the participants open their feet shoulder-width apart and squat to the sides with their bodies upright.

Walking Quad Stretch

The participant bends the knee of the same lower extremity, catches the hand and foot of the same extremity behind, and holds it for 2 seconds. He relaxes and takes a step forward, and performs the same movement on the opposite side.

Monster Walks

The participant bends their knees and comes to a slightly squatting position. She can put her hands on her thighs and start walking, leaning slightly forward.

Inverted Hamstring Stretch

The participant opens his lower extremity at shoulder width and raises his hands. As he pushes his hips back, he begins to bring his torso slightly towards the ground. Simultaneously raise the right/left leg back (parallel to the ground). Furthermore, when he feels the stretch, he returns to the starting position.

Multidirectional Lunges

The participant puts their feet hip-width apart. Slowly positions the right leg forward. The trunk should be standing upright. Then he begins to bend the right knee. At the same time, he bends his left knee towards the ground and can lift his left heel slightly off the ground.

Nordic Hamstrings

Participants perform this exercise with a partner. The partner fixes the participant by the ankles . The participant takes the position for the exercise with the body upright on their knees. Hands are crossed on the chest. The body is slowly brought closer to the ground without disturbing its alignment, and it is turned from the point where it can be turned without assistance.

Single Toe Raises

The participant stands with his/her body straight and feet shoulder-width apart. Lifts one leg off the ground and bends the knee slightly. He raises his heel off the ground and slowly lowers it back as if pushing the ground with the toes of the grounded leg.

Lateral Bridge

The participant starts lying on his right side, and the body's load is on the right elbow. His lower extremities are straight, and his left foot is on his right foot. While exhaling, he lifts his pelvis off the ground and is asked to maintain this position. The body's alignment should not be disturbed during the exercise, and the pelvis should not fall.

Vertical Jumps

The participant comes into a squatting position by bending their hips, knees and ankles. Furthermore, by applying a thrust towards the ground, he jumps his body upwards in an explosive motion.

Lateral Hops

The participant stands on both legs and connects their legs. He puts his hands on his hips and feels as if their hips are level. He then performs repeated jumps to the right and left.

3.2 EVALUATION

3.2.1 Demographic characteristics of the participants

Demographic information of the participants was collected with a form called "General Information Evaluation Form". Participants filled the forms face to face before the evaluation day(APPENDIX 3). The following information was collected through the form.

- Participant's age, height (cm), weight (kg), body mass index (BMI),
- Gender (female / male),
- Dominant side
- Whether there is any medical diagnosis,
- Whether they have brain, sensory, balance or vestibular problems,
- Whether there is any surgical applications,
- Whether there is an additional assistive device used,
- Drug use
- HES codes

3.2.2 Assessments of Balance

The Y balance test was initially adapted from the Star Balance Test, were reaching in eight different directions was evaluated, and the directions of reachings were reduced to three (anterior, posteromedial, posterolateral). The Y balance test evaluates the participant's balance and stability with one lower limb while reaching in determining directions over the other. In addition, the Y balance test is a closed kinetic chain exercise, so it requires strength in the limb, proprioception, neuromuscular control, and an adequate lower extremity range of motion. Participants stand in the centre of a 3-lined 'Y' shaped setup drawn at certain angles for this test. Participants are asked to reach out in the anterior, posterolateral and posteromedial directions using one foot. Participants should touch the furthest distance as far as they can with their reach leg. Three reachings are made in each direction, and the average of the reaching distances are recorded in centimetres. To normalize these three reachings' average score, previously measured leg length was used. The percentage of maximum reach distance = excursion distance/leg length. Leg length was defined as; from the anterior superior iliac spine to the distal point

of the medial malleolus. To get a global measure of the Y Balance Test, data from each direction must be averaged for calculating the composite score. There is a 30-second break after each reach. Inter-rater and inter-rater reliability of the Y Balance test was found to be relatively high (95% CI: 0.88-0.99 p <0.01) (51–53).

3.2.3. Vertical Jump Test

The Vertical Jump Test is used for the evaluation of muscular power in the lower extremities. The maximum jump height reached provides information about the lower extremities' muscle power and functional capacity in many sports (54). It is a simple test to apply. A wall and chalk are required to mark fingers. Test-retest reliability was reported between 0.93 and 0.99 (55).

They keep the feet flat on the ground. The point of the fingertips reached was recorded. This was called the standing reach height. The athletes then stood away from the wall, began in a knee-extended stance with the feet shoulder-width apart. The athlete flexed his/her knees and hips and then jumped. The athlete reached the highest point that he could reach with his hands. The length of this point was recorded. The test was applied three times, and the highest distance was used as a jump height (56).

3.2.4. McGill Trunk Endurance Test

The test consists of 4 parts. There is a 5-minute break between each test.

3.2.4.1. Trunk Flexor Muscle Endurance Assessment

Evaluation of trunk flexor muscle endurance is performed by timing with a stopwatch. The starting position of the assessment, the individual, measured is hip 90-degree flexion, knees 90-degree flexion and trunk 60-degree angle with the bed. Until the beginning of the evaluation with the stopwatch, a rigid triangular pillow with an angle of 60-degree with the bed on its back is positioned for support to prevent the individual from getting tired and maintain the starting position. The feet of the individual are fixed to the bed with the help of a belt. In the evaluation, with the start of the stopwatch period, a solid triangular pillow at an angle of 60 degrees to the bed supporting the body is pulled; the individual is asked to keep the initial position for a maximum time by crossing the hands on the chest with an isometric contraction. The evaluation is concluded with the distortion

of the body's 60-degree angle with the bed, separation of the hands from the crossed position, the protrusion of the shoulders or the formation of a kyphotic posture (57).

3.2.4.2. Right and Left Lateral Trunk Muscle Endurance Assessment

Lateral trunk muscle endurance is evaluated by timing with a stopwatch. The starting position of the assessment the individual measured is in the side-lying position. In the evaluation, with the onset of the chronometer period, the individual is asked to contract the lateral trunk muscles isometrically and maintain the position for a maximum time so that only the lower foot and forearm contact the bed. The upper arm of the individual should be positioned in contact with the body. Three measurements are taken for both sides by making the bilateral evaluation, and the arithmetic average of 3 measurements is taken. The assessment is terminated by swinging the individual's hip forward, backward or downward (57,58).

3.2.4.3. Back Extensor Muscle Endurance Assessment

The evaluation of the back extensor muscle endurance is performed by timing a stopwatch. The starting position of the assessment should be such that the SIAS line touches the bed at the edge of the bed while the individual measured is in the prone position. The feet of the individual are fixed to the bed with the help of a belt. In the evaluation, at the beginning of the stopwatch period, the individual is asked to keep his position for a maximum time by crossing his hands on his chest, and isometric contraction with the body parallel to the ground. The evaluation is terminated when the individual disrupts the position of the body parallel to the ground, and the hands are separated from the cross position (57,59).

3.3 Intervention

3.3.1 Neuromuscular Training Program

Exercises (Table 3.1) were taught to the experimental group in the presence of a physiotherapist. Furthermore, it was applied twice a week for six weeks. The content of the program includes core stabilization, balance and plyometric exercises. Examples of exercises used in the study are shown in the figures below.

Figure 3. 2 (A) Jog (B) Shuttle run (C-D)Leg swing front to back side to side (E) Inverted hamstring stretch (F) Lunge superior reach (G) Monster walk (H) Walking quad stretch (I) Lateral squats

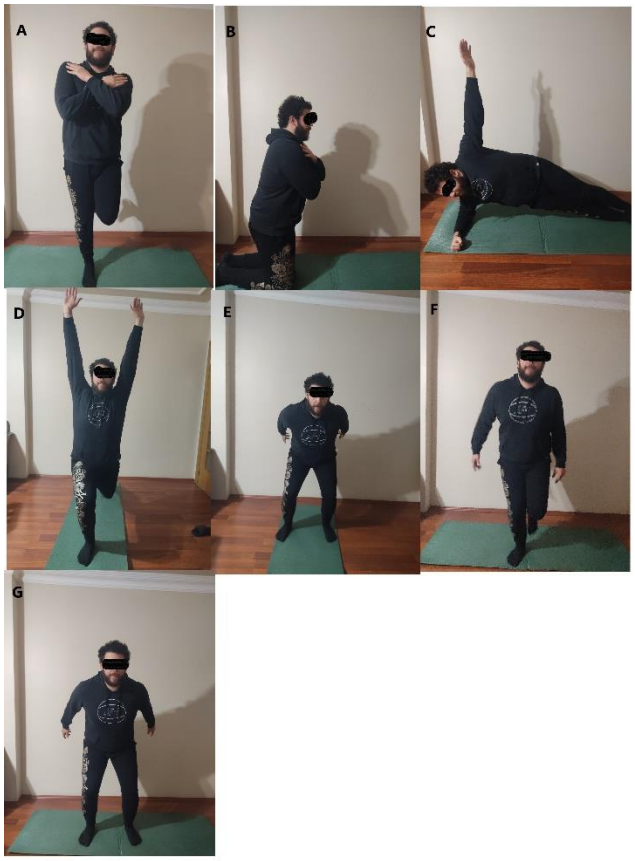

Figure 3. 3 (A)Single toe raises (B)Nordic hamstring (C) Lateral bridge (D) Multidirectional lunges (front) (E) Vertical jump (F) Single legged hops (G) Forward hops

3.3.2 Traditional Training Program

All athletes participating in the study continued their traditional training programs for six weeks. The traditional training program included strength, technical and tactical training, warm-up and cool-down. This training program was carried out under the supervision of trainers for one and a half - 2 hours..

3.4 Statistical Analysis

PS: Power and Sample Size Calculation version 3.1 was used when calculating the study's sample size. In a previous study, the response within each group of subjects

was normally distributed with a standard deviation of 3.2. If the true difference between the experimental and control means is 3.5, we will need to study 16 experimental and 16 control subjects to reject the null hypothesis that the population means of the experimental and control groups are likely to be equal. Power = 0.85 (60).

Statistical Package for Social Science (SPSS) 25.0 was used to analyse the data obtained in our study. The " Kolmogorov- Smirnov " test statistic examined whether the variables conformed to the normal distribution was examined using the "Kolmogorov – Smirnov" test statistic. "Wilcoxon Signed-Rank" was used for intragroup comparisons of data that did not show normal distribution. In the comparisons between groups, analysis was made with the "Mann-Whitney U" test and Independent Sample t-Tests. In all statistical analyses, $p<0.05$ was considered statistically significant.

4. RESULTS

4.1. Descriptive Characteristics of Participants

16 volunteer(n=16) amateur adolescent male basketball players participated in the study. The demographic characteristics of the participants (age, height, weight, BMI) are shown in Table 4.1. There was no statistically significant difference between the two groups in terms of demographic characteristics. Therefore, the two groups were statistically comparable (Table 4.1).

Table 4.1 Physical Features of Participants

	NMTG (n=8) mean±SD	**CG (n=8)** mean±SD	**z**	**p value**
Age(year)	15,62 ± 0,51	15,37 ± 0,51	-0,96	0,33
Weight(kg)	75,68 ± 9,73	69,55 ± 11,07	-1,21	0,22
Height(cm)	180,87 ± 8,54	175,12 ± 9,24	-1,21	0,22
BMI(kg/m^2)	23,18 ± 2,88	22,61 ± 2,72	-0,36	0,71

Data expressed as mean ± standart deviation. NMTG: Neuromuscular Training Group, CG: Control Group.

4.2. Participants' Years of Playing Basketball

According to the data obtained from the demographic information of the participants, the basketball experience periods are shown in Figure 4.1.

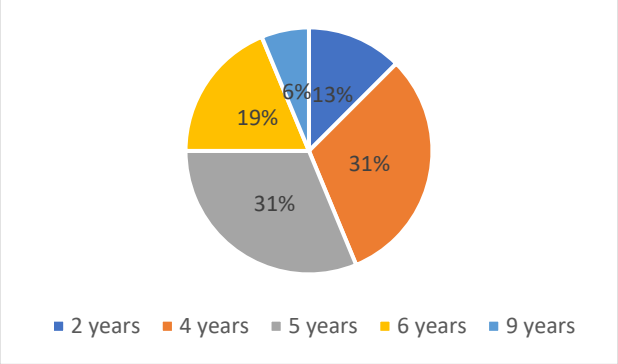

Figure 4. 1 Participants' Years of Playing Basketball

4.3. Participants' Dominant Sides

The dominant sides of the participants are shown in figure 4.2.

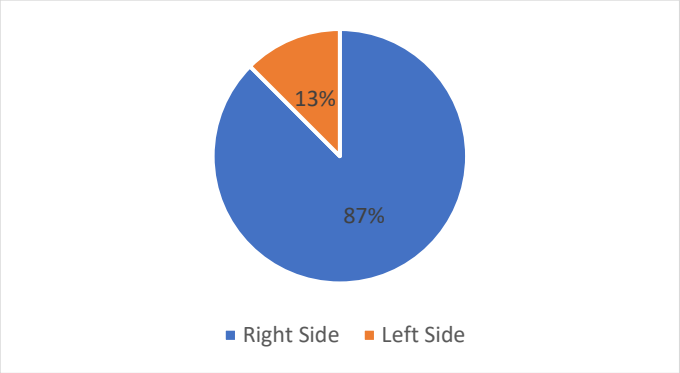

Figure 4. 2 Dominant Sides of Participants

4.4 Intragroup Comparison of Pre-Post Measurement Findings of Y Balance

Since the data were not normally distributed, the Wilcoxon Signed-Rank test was used for Y Balance pre-post comparisons within the group. Intra-group comparisons of the Y Balance Test in both groups are shown in Table 4.2. A statistically significant difference was found in NMTG in all measured parameters of Y balance (p<0,05). However, no statistically significant difference was found between pre-post measurements in any parameter of Y Balance in CG (p >0,05) (Table 4.2).

Table 4.4. Comparison of Y Balance Measurements for Intragroup Variables

				NMTG mean±SD	**p/z**	**CG** mean±SD	**p/z**
Y BALANCE	Right	Anterior	Pre	72,94 ± 7,19	**p:0,01** z:-2,36	70,08 ± 11,90	p:0,22 z:-1,21
			Post	76,75 ± 6,69		71,87 ± 9,24	
		Posteromedial	Pre	79,25 ± 10,83	p=**0,02** z=-2,19	77,21 ± 9,28	p=1,0 z=0,00
			Post	82,07 ± 11,21		77,21 ± 8,42	
		Posterolateral	Pre	73,07 ± 10,64	p=**0,02** z=-2,19	74,49 ± 6,59	p=0,61 z=-0,5
			Post	75,37 ± 10,16		73,6 ± 67,11	
	Left	Anterior	Pre	73,93 ± 5,37	p=**0,01** z=-2,37	81,13 ± 9,59	p=0,34 z=-0,94
			Post	77,22 ± 5,50		81,52 ± 9,46	
		Posteromedial	Pre	80,02 ± 11,97	p=**0,01** z=-2,36	80,04 ± 12,14	p=0,24 z=-1,15
			Post	82,90 ± 11,88		79,35 ± 12,72	
		Posterolateral	Pre	71,68 ±11,30	p=**0,02** z=-2,2	76,52 ± 8,17	p=0,34 z=-0,94
			Post	74,27 ± 10,78		75,87 ± 7,45	

Data expressed as mean ± standart deviation. NMTG: Neuromuscular Training Group, CG: Control Group

4.5. Intragroup Comparison of Pre-Post Measurement Findings of Vertical Jump and Mcgill Endurance Parameters

Since the data were not normally distributed, the Wilcoxon Signed-Rank test was used for Vertical Jump Test and the McGill Endurance Test pre-post comparisons within the group. Intra-group comparisons of the Vertical Jump Test and McGill Endurance test in both groups are shown in Table 4.3. There was no statistically significant difference between the measurements of the two groups before and after the Vertical Jump Test ($p > 0,05$). A statistically significant difference was found between pre-post measurements in all parameters of the McGill Endurance Test in NMTG ($p<0,05$). In CG, a statistically significant difference was found between the pre and post measurements only in the Extensor parameter of the McGill Endurance Test ($p<0,05$) (Table 4.3)

Table 4.5. Comparison between Pre/Post Vertical Jump and Mcgill Endurance Parameters

			NMTG mean±SD	**p/z**	**CG** mean±SD	**p/z**
Vertical Jump(cm)		**Pre**	24,45±7,07	p=0,68	41,56±11,62	p=0,59
		Post	24,52±6,46	z=-0,4	41,41±11,38	z=-0,5
McGill Endurance Test(s)	**Flexor**	**Pre**	92,12±34,74	p=**0,01**	53,62±21,28	p=0,46
		Post	97,75±36,28	z=-2,53	54,5±20,24	z=-1,46
	Right Side	**Pre**	21,62±17,35	p=**0,01**	18,62±11,01	p=0,15
		Post	28,25±16,42	z=-2,53	20,00±9,98	z=-1,41
	Left Side	**Pre**	30,25±16,26	p=**0,01**	18,75±6,92	p=0,16
		Post	35,37±16,13	z=-2,37	19,75±6,62	z=-1,37
	Extensor	**Pre**	31,12±29,56	p=**0,01** z=-2,53	18,25±9,54	p=**0,01** z=-2,38
		Post	38,75±28,28		20,25±8,77	

Data expressed as mean ± standart deviation. NMTG: Neuromuscular Training Group, CG: Control Group.

4.6. Intergroup Comparison of Difference Between Y Balance Test Measurements

Comparison between two groups interms of Y Balance Test was performed with Mann Whitney U test. Intergroup comparisons of the difference between Y Balance Test measurements are shown in Table 4.4. A statistically significant difference was found in all parameters except the Right Anterior Y Balance measurement ($p<0.05$).

Table 4.6. Comparison of Difference Between Y Balance Test Measurements

			NMTG mean±SD	**CG** mean±SD	**U**	**p**
Y BALANCE	Right	ΔAnterior	3,81 ± 2,33	1,78 ± 4,38	14,50	0,06
		ΔPosteromedial	2,82 ± 2,36	-0,00 ±1,86	10,50	**0,02**
		ΔPosterolateral	2,29 ± 2,13	-0,83 ± 2,98	8,50	**0,01**
	Left	ΔAnterior	3,28 ± 1,43	0,38 ± 2,24	6,00	**0,006**
		ΔPosteromedial	2.88 ± 1,52	-0,69 ± 1,11	3,00	**0,002**
		ΔPosterolateral	2,59 ± 2,05	-0,65 ± 2,06	8,00	**0,01**

Data expressed as mean ± standart deviation. NMTG: Neuromuscular Training Group, CG: Control Group, Δ: PostMeasurement – PreMeasurement.

4.7. Intergroup Comparison of Difference Between Vertical Jump and McGill Endurance Test

Comparison between two groups in terms of Vertical Jump and McGill Endurance Test were performed with Mann Whitney U test. Intergroup comparisons of the difference between Vertical Jump and McGill Endurance Test were shown in Table 4.5. There was no statistically significant difference between the measurements of the Vertical Jump Test ($p>0.05$). There was a statistically significant difference between the two groups in terms of all parameters of the McGill Endurance Test ($p<0.05$).

Table 4.7 Comparison of Difference Between Vertical Jump Test and McGill Endurance Test Measurements

		NMTG mean±SD	**CG** mean±SD	**U**	**p**
Δ Vertical Jump(cm)		0,06 ± 1,51	-0,15 ± 0,75	23,50	0,36
McGill Endurance Test(s)	**ΔFlexor**	5,62 ± 2,55	0,87 ± 1,45	0,50	**0,001**
	ΔRight Side	6,62 ± 2,44	1,37 ± 2,72	4,50	**0,003**
	ΔLeft Side	5,12 ± 2,90	1,00 ± 1,85	8,00	**0,01**
	ΔExtensor	6,62 ± 3,24	2,00 ± 1,51	5,00	**0,004**

Data expressed as mean ± standart deviation. NMTG: Neuromuscular Training Group, CG: Control Group Δ: PostMeasurement – PreMeasurement.

5. DISCUSSION

This study investigates the effects of the neuromuscular exercise program applied in adolescent basketball players on balance, vertical jump, and core endurance. After the NMT program was applied, in addition to traditional training, balance, vertical jump and core endurance tests were performed, and these parameters were compared with the group that continued traditional training. According to the results, it was found that there was a significant difference in balance and core endurance parameters in the NMT group compared to the group that continued the traditional training program. As a result of the vertical jump evaluation, there was no significant difference between the two groups..

The exercises were chosen considering the injury prevention NMT programs in the literature (6,61,62). The exercise program used in the study was adapted from the study by Bonato et al. (12). While the exercises were taught and performed, verbal and visual feedback was provided by the coach and physiotherapist to perform the movements biomechanically correctly. Studies in the literature emphasise the importance of supervising the participants while performing neuromuscular exercises (10,63). In this way, wrong movement patterns can be prevented, and the NMT program can be applied correctly under the supervision of a physiotherapist and coach.

In our study, the NMT program was added to the warm-up routine to increase the application rate, and the application time varied between 25-30 minutes. In a systematic review, the compliance rates of programs lasting up to 25 minutes were found to be over 75%(64). We also used an equipment-free, bodyweight NMT program to increase the rate of compliance.

In the present study, Y-Balance test was used in the dynamic balance evaluations of our participants. YBT is a variation of SEBT used as a screening test in patients with dynamic balance limitations (52). Our balance findings showed a significant difference in every direction of YBT in the NMT program applied group on both sides of the lower extremity except the Right Anterior Side. Also, there was no significant difference in the balance parameter in the group that continued the traditional training program.

Benis et al. investigated the effect of body-weight neuromuscular training on YBT for the right and left legs. (38). The study was conducted on 28 healthy elite female

basketball players and showed that the NMT program with bodyweight significantly affected postural control and lower extremity stability.

Filipa et al studied the effect of NMT program in 20 female soccer players on SEBT (65). The program in their study focused on core stabilization and lower extremity strength. In our study, the NMT program consisted of balance, plyometric, mobility and core stabilization exercises. However, they showed that the NMT program they applied in their study significantly affected the SEBT test results except for the anterior direction.

In a randomized controlled study, Sato et al. examined the effect of a 6-week core strength training program on lower extremity stability (66). Lower extremity stability was evaluated with SEBT. In this study conducted on 20 people, significant results were not obtained on SEBT. However, these results may be because balance training was not used in the program's content in this study, and the protocol of SEBT was different.

Motealleh et al. investigated the effects of the NMT program on 28 women with patellafemoral pain syndrome in their clinical study (67). In the study, the typical physical therapy exercise protocol was applied to one group, while the NMT program was applied to another group in addition to routine physical therapy applications. Dynamic balance assessments were performed with YBT, and after the application, a significant difference was found in both groups in all directions of YBT. In the group that applied for the NMT program, the improvement was only significant in the posteromedial direction compared to the other group.

The results in the literature support our study. Unlike studies in the literature, our exercise program includes exercises in all directions and trains both extremities may have enabled us to find a significant difference in every direction (except the Right Anterior direction) in YBT. In our study, the lower extremity strength of the participants was not evaluated. However, a study in the literature shows a positive correlation between lower extremity strength and YBT scoring. Plisky et al. showed that women who performed poor scores on YBT were more prone to non-contact lower extremity injuries (53). Although the effect of the NMT program on the injury was not examined in our study, YBT can also be used to evaluate athletes in terms of lower extremity injury risk.

In this study, the VJT was used to evaluate the vertical jump heights of the participants. In our study, there was no significant difference between the two groups after the 6-week NMT program. Myer et al. showed a significant difference in female athletes' vertical jump, single leg jump, and speed parameters after the NMT protocol they applied for six weeks (68). Unlike our study, the protocol of Myer et al. lasted approximately 90 minutes and was applied three days a week..

In the randomized controlled study by Jacopo et al.; Elite skiers were divided into two groups, and the NMT program was applied to one group for eight weeks (2 times a week), and the other group continued their traditional training (69). In the study, the dynamic balance was evaluated with YBT and jump height was evaluated with countermovement jump(CMJ) and drop jump(DJ). The YBT results of the study were supportive of our study, and at the end of 8 weeks, a significant difference was found in all directions in YBT. Unlike Myer et al., no significant difference was found in jump heights in the two tests in this study.

In another study, Akbari et al. applied FIFA 11+ three times a week for eight weeks (56). The study population was male football players, and at the end of 8 weeks, the vertical jump parameters of the football players were evaluated with the vertical jump test. After the post-test evaluations, a significant difference was found in the vertical jump values of the group that applied FIFA 11+.

The effects of the NMT program on jumping are controversial in the literature. In the study of Akbari et al., FIFA 11+ was designed entirely for football, and there is no such NMT program designed for basketball in the literature yet within our knowledge. There are significant effects on jumping in studies with an application time of 60-90 minutes (70,71), and in our study, the NMT program was used for warm-up purposes and lasted an average of 25-30 minutes. At the same time, due to pandemic conditions, the NMT program was applied twice a week for six weeks in our study. This period of exercising may not be enough to make a significant difference in the vertical jump parameter.

The literature has reported that a well-trained core region is essential for optimal performance and injury prevention in athletes (72). In our study, the McGill Core Endurance test was used to evaluate the core endurance parameter. In the McGill

Endurance test, the flexor, extensor and right/left regions' endurance were measured. In the comparison of the two groups, significant differences were found between EG and CG.

There is only one study in the literature that measures the effect of an NMT program on the core endurance parameter as far as we know. Barber-Westin et al. applied for a 6-week neuromuscular and performance program in their study on 42 tennis players (73). They used the Abdominal Endurance test for Core endurance parameter evaluation in their study. At the end of 6 weeks, they revealed that core endurance had improved significantly. Unlike our study, only anterior group muscles are evaluated in the abdominal endurance test.

Ambegaonkar et al. examined the relationship between balance, core endurance and hip strength in their study (74). They evaluated the core endurance parameter with MCET similar within our study and revealed that core endurance and hip strength did not affect SEBT scores. Abhilash et al. showed a positive correlation between core endurance and SEBT scores in their study on 20 professional basketball players (74). Although this correlation was not evaluated in our study, the core stabilization exercises included in the NMT program used in our study may affect dynamic balance.

6. CONCLUSION

In conclusion, this study showed that the 6-week NMT program had significant effects on balance and core endurance but did not find a significant difference between the two groups on vertical jump parameters. The following points can be taken into account as a result of this study:

- Warm-up programs on neuromuscular control may increase lower extremity awareness and improve postural control in adolescent basketball players.
- Using a sport-specific NMT program can improve the performance of athletes and prevent them from injury. Core endurance parameter should be considered while preparing the NMT program for adolescent basketball players. Adequate activation of the core area may positively affect the performance of the players.
- We recommend the program we used in our study for future studies. As far as we know, there is no NMT program specifically designed for basketball in the literature. As the effects of NMT programs on performance are proven, the rate of complain of the programs will increase.

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8. APPENDIXES

8.1 Appendix 1 Informed Written Consent

BİLGİLENDİRİLMİŞ EBEVEYN/AİLE OLUR FORMU

Yeditepe Üniversitesi, Sağlık Bilimleri Fakültesi, Fizyoterapi ve Rehabilitasyon Bölümü olarak Nöromuskuler ısınma programının basketbolcular üzerindeki etkilerini araştırmayı planlamaktayız

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

Çocuğunuzun araştırmaya davet edilmesinin nedeni ; basketbol yaralanmaların çok sık görüldüğü spor branşıdır. Yaralanmalardan koruyucu nöromuskuler ısınma programlarının yaralanma oranlarını azalttığı görülmektedir. Bu çalışma ile 6 hafta uygulanacak olan nöromuskuler ısınma programının basketbolcuların denge , dikey sıçrama ve gövde kaslarının dayanıklılığı üzerine etkisi araştırılacaktır. Çalışma kapsamında iki gruba bölünülecek ve bir grup geleneksel antrenmanına devam ederken bir grup nöromuskuler ısınma programını uygulayacak.(6 hafta boyunca haftada 2 kez)

Araştırmaya katılmayı kabul ederseniz, çocuğunuzun değerlendirmeleri Fzt. Doğukan TONGAR tarafından yapılacak ve bulgular kaydedilecektir. Araştırma kapsamında , çocuğunuza girişimsel olmayan fiziksel değerlendirmeler ve performans testleri uygulanacaktır. Çalışmaya katılmakla herhangi bir parasal yük altına girmeyeceksiniz ve aynı şekilde bir ödeme yapılmayacak Araştırmada yapılacak değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmada kullanılacaktır. Bu amaçların dışında bu kayıtlar kullanılamayacak ve başkalarına verilmeyecektir. Araştırma bir kongrede ya da dergide yayın olarak kabul edilse bile çocuğunuzun kimliğini ortaya çıkarabilecek kayıtlar gizli tutulacaktır. Araştırmaya katılım tamamen isteğe bağlıdır , istediğiniz zaman herhangi bir ceza veya yaptırıma maruz kalmaksızın araştırmadan çekilebilirsiniz.

Değerlendirme Yöntemleri

- **Y Denge Testi :** Katılımcıların dinamik dengesi Y şeklindeki bir platformda değerlendirilecektir.
- **Dikey sıçrama testi**: Katılımcı duvar yanında ayakta iken dominant eli ile duvarda ulaşabildiği en yüksek noktaya ulaşması istenir ve o nokta işaretlenir. Katılımcının sıçrayarak duvarda ulaştığı en yüksek nokta işaretlenerek başlangıç noktası ile arasındaki mesafe kayıt edilecektir. Test ile katılımcının alt ekstremite gücü ölçülecektir
- **Omurganın ön, arka ve yan grup kaslarının dayanıklılık testleri:** Bu testlerde omurganın ön, arka ve yan grup kaslarının dayanıklılıkları, katılımcıların farklı pozisyonları koruyabilme süreleri kayıt edilecektir. Süreler kronometre kullanılarak değerlendirilecektir.

Çalışma ile koruyucu egzersiz programının basketbolcularda dinamik denge , dikey sıçrama ve gövde kaslarının dayanıklılığı üzerine etkisi araştırılacaktır.

SORUMLU ARAŞTIRMACILAR:

Prof. Dr. Feryal SUBAŞI – Fzt. Doğukan TONGAR

İLETİŞİM:Fizyoterapist Doğukan Tongar

+90 0507 843 10 21

" NÖROMUSKULER ISINMA PROGRAMININ ADÖLESAN DÖNEM ERKEK BASKETBOLCULAR ÜZERİNE 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:	Adres:	Telefon:
İmza:	İmza:	İmza:
Tarih:	Tarih:	Tarih:

8.2. Appendix 2 Ethical Committee Approval

T.C. YEDİTEPE ÜNİVERSİTESİ
GİRİŞİMSEL OLMAYAN KLİNİK ARAŞTIRMALAR
ETİK KURULU

Versiyon No 1.0

KARAR FORMU

3.07.2021

ETİK KURUL BİLGİLERİ		
	Etik Kurulun Adı	Yeditepe Üniversitesi Girişimsel Olmayan Klinik Araştırmalar Etik Kurulu
	Açık Adres	Yeditepe Üniversitesi Diş Hekimliği Fakültesi, Bağdat Cad. No. 238 Göztepe 34728 Kadıköy, İstanbul
	İnternet Sayfası	http://goetik.yeditepe.edu.tr/
	Telefon	0216 363 60 44
	E-posta	goetik@yeditepe.edu.tr

DEĞERLENDİRİLEN BELGELER	
	Islak imzalı başvuru dosyası, CD'si ve elektronik başvuru ☒
	Araştırma başlığı ve araştırmacıların isimleri ☒
	Başvuru dilekçesi ☒
	Araştırmanın; ☒
	• Niteliği ☒
	• Önemi ve özgün değeri ☒
	• Amaç ve hedefleri ☒
	• Yöntemi ☒
	• Yönetimi ☒
	• Yaygın etkisi ☒
	• Araştırma bütçesi (Mevcutsa) ☒
	• Süresi ve uygunluğu (Zaman cetveli) ☒
	• Kaynakları ☒
	Araştırma izin belgesi / belgeleri ☒
	Bilgilendirilmiş Gönüllü Olur Formu (yapılan araştırmaya özel olarak hazırlanmış) ☒
	Taahhütname-1 ☒ Dünya Tıp Birliği Helsinki Bildirgesinin son versiyonunun ve Sağlık Bakanlığı'nın ilgili tüm kılavuzlarının okunmasına dair taahhüt
	Taahhütname-2 ☒ Daha önce yapılmış etik kurul başvuruları mevcut olup olmadığına dair taahhüt
	Taahhütname-3 ☒ Araştırma sırasında araştırma bütçesinde yer almayan ve gönüllünün kendisine veya Sosyal Güvenlik Kurumuna ek yük getirecek hiçbir işlem uygulanmayacağına dair taahhüt
	Taahhütname-4 ☒ COVID-19 hastalarında tedavi yaklaşımları ve bilimsel araştırmalar genelgesi okunmasına dair taahhüt
	Araştırmacıların her birisine ait özgeçmiş formu ☒
	Ek belgeler (Varsa kullanılan ölçek izinleri vb.) ☒

KARAR BİLGİLERİ		
	Başvuru Numarası	202105033
	Toplantı Tarihi	21.06.2021
	Toplantı Yeri	Çevirim içi (Google Meet)
	Karar No	13

Araştırmanın Başlığı	**Nöromuskuler ısınma programının adölesan dönem erkek basketbolcular üzerine etkileri**
Araştırmacılar	**Prof. Dr. Feryal Subaşı, Fzt. Doğukan Tongar**

BAŞVURU NUMARASI: 202105033

KARAR 3.07.2021

☒ KABUL	☐ RET ☐ *KAPSAM DIŞI (GİRİŞİMSEL)* ☐ *BİLİMSEL VE/VEYA ETİK KURALLARA AYKIRI* ☐ *BİR SORUMLU ARAŞTIRMACININ (TEZ İSE TEZ DANIŞMANI), BİR TOPLANTIYA **İKİ (2) ADETTEN FAZLA ÇALIŞMA BAŞVURUSUNDA** BULUNMASI* ☐ *KURUM İÇİ BAŞVURULARINDA **YEDİTEPE UZANTILI E-POSTA HESABI** İLE GİRİŞ YAPILMAMIŞ OLMASI* ☐ *ŞARTLI KABULDE BELİRTİLEN REVİZYONLARIN ZAMANINDA VE/VEYA İSTENİLDİĞİ ŞEKİLDE YAPILMAMIŞ OLMASI*

Prof. Dr. Didem ÖZDEMİR ÖZENEN **Başkan**				**Doç. Dr. Gökhan ERTAŞ** **Başkan Yardımcısı**				**Doç. Dr. Elif SUNGURTEKİN EKÇİ** **Raportör**			
Katılım		İlişki		Katılım		İlişki		Katılım		İlişki	
☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok
Prof. Dr. Feryal SUBAŞI **Üye**				**Prof. Dr. Şenay UZUN** **Üye**				**Doç. Dr. Mehmet Engin CELEP** **Üye**			
Katılım		İlişki		Katılım		İlişki		Katılım		İlişki	
☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok
Dr. Öğr. Üyesi E. Çiğdem ALTUNOK **Üye**				**Dr. Öğr. Üyesi Binnur OKAN BAKIR** **Üye**				**Dr. Öğr. Üyesi E. Nur ÖZDAMAR** **Üye**			
Katılım		İlişki		Katılım		İlişki		Katılım		İlişki	
☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok

Araştırmanın Başlığı	**Nöromuskuler ısınma programının adölesan dönem erkek basketbolcular üzerine etkileri**
Araştırmacılar	**Prof. Dr. Feryal Subaşı, Fzt. Doğukan Tongar**

8.3. Appendix 3 Structured Questionnaire for Athlete's Demographic Characteristics

Demografik Bilgilendirme Formu

GENEL BİLGİLER

Adı-Soyadı:

Yaş:

Cinsiyet:

Boy:

Vücut Ağırlığı (kg):

VKI:

Dominant Taraf: Sağ ( ) Sol ( )

1. **Herhangi bir tıbbi teşhisiniz var mı?**

( ) Evet – Eğer evet ise, nedir? _____

( ) Hayır

2. **Düzenli olarak kullandığınız herhangi bir ilaç var mı?**

( ) Evet – Eğer evet ise, nedir? _____

( ) Hayır

3. **Herhangi bir ameliyat geçirdiniz mi?**

( ) Evet

( ) Hayır

Eğer evet ise, lütfen hangi işlem olduğunu belirtiniz._____

Operasyon ne zaman yapıldı?_____

4. **Herhangi bir yardımcı cihaz kullanıyor musunuz?**

( ) Evet

( ) Hayır

5. **Herhangi bir sistemik (kalıcı) bir hastalığınız var mı?**

( ) Hayır

( ) Vestibüler (Denge ile ilgili) hastalıklar

( ) Kardiyovasküler Hastalıklar (kalp yetmezliği, ritim bozukluğu, tansiyon, anemi vb.)

( ) Solunum Hastalıkları (Astım, Alerji, KOAH vb.)

( ) Kulak Bozuklukları (İşitme sorunları vb.)

( ) Sinir sistemi Bozuklukları (Vertigo, epilepsi, nöropati, his kaybı vb.)

( ) Enfeksiyon Hastalıkları (Bademcik iltihabı, otitis vb.)

( ) Hormonal Bozukluklar (Diyabet, guatr, insülin direnci vb.)

( ) Kas İskelet Hastalıkları (Kas, Eklem, Tendon, Romatoid hastalıkları vb.)

( ) Sindirim Sistemi, Metabolizma Bozuklukları (Gastrit, ülser, ülser, bağırsak hastalıkları vb.)

( ) Görme Bozukluğu

AKTİVİTE BİLGİLERİ

6. **Egzersiz yapıyor musunuz? Evet ise, ne sıklıkla egzersiz yaparsınız?**

( ) Yapmıyorum

( ) Haftada 1-2 kez

( ) Haftada 3-4 kez

( ) Her gün

( ) Ayda 3 günden az

Egzersiz yapıyorsanız, her egzersiz en az kaç dakika sürer? _____

7. **Yapmayı tercih ettiğiniz spor nedir?**

( ) Futbol ( ) Basketbol ( ) Voleybol ( ) Tenis ( ) Koşu ( ) Yüzme

Diğer _____

8. **Spor yapanlar için, sporunuz her seferinde kaç dakika sürüyor?**

( ) 20 dakika veya daha kısa

( ) 21-30 dakika

( ) 31-50 dakika

( ) 50 dakikadan daha fazla

ALT EKSTREMİTENİN DEĞERLENDİRİLMESİ (KALÇA, DİZ, AYAK BİLEĞİ, AYAK)

9. Son altı ayda alt ekstremitelerinizden (kalça, diz, ayak bileği, ayak) yaralandınız mı?

( ) Hayır

( ) Kalça ( ) Diz ( ) Ayak bileği ( ) Ayak

10. Son altı ayda alt ekstremite (kalça, diz, ayak bileği, ayak) ameliyatı oldunuz mu?

( ) Hayır ( ) Evet - Evet ise lütfen belirtiniz. _____

11. Hiç ayak bileği burkulmanız oldu mu?

( ) Evet ( ) Hayır (Hayır ise, 17. soruya geçin)

12. Hangi tarafta burkulma yaşadınız?

( ) Evet ( ) Hayır

13. Burkulma ne kadar önce oldu?

( ) Son 1 ay ( ) Son 6-12 ay ( ) Son 12-24 ay ( ) 24 aydan daha fazla

14. Hiç aynı ayak bileğinizde tekrarlayan bir burkulma oldu mu?

( ) Evet – Evet ise, kaç kez?

( ) Hayır

15. Burkulma şikayetinizden sonra fizik tedavi gördünüz mü?

( ) Evet

( ) Hayır – Hayır ise, 17. soruya geçin.

16. Fizik tedavi aldığınız tarih nedir?_____

17. HES kodunuzu yazınız. _____

18. Kaç yıldır basketbol oynuyorsunuz?

19. Son 6 ay içerisindeki yaralanam geçmişiniz.

20. Haftada kaç antrenman yapıyorsunuz ?

8.4 Appendix 5 Institutional Permission Letter Showing That The Study Can Be Done

T.C. YEDİTEPE ÜNİVERSİTESİ
GİRİŞİMSEL OLMAYAN KLİNİK ARAŞTIRMALAR
ETİK KURULU

Versiyon No
1.0

EK 1. ARAŞTIRMA İZİN BELGESİ

19 Mart 2021

T.C. YEDITEPE ÜNİVERSİTESİ

GİRİŞİMSEL OLMAYAN KLİNİK ARAŞTIRMALAR ETİK KURULU BAŞKANLIĞI' NA,

Sorumlu araştırmacısı olan Nöromuskuler Isınma Programının Adölesan Dönem Erkek Basketbolcular Üzerine Etkileri başlıklı araştırma önerisinin veri toplama kısmı kurumumuzda yapılacaktır. Gereğini arz ederim.

Kurum Bilgileri

Adı	Anabilim Dalı / Bölüm Adı
Dostluk Spor Kulübü	**Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü Spor Fizyoterapisi Yüksek Lisans Programı**

Kurum Yetkilisi

Ünvanı, Adı - Soyadı	Görevi	İmza
Mahmut Güngör	**Antrenör**	

Araştırmanın Başlığı **Nöromuskuler Isınma Programının Adölesan Dönem Erkek Basketbolcular Üzerine Etkileri**

Araştırmacılar **Subaşı F. , Tongar D.**

8