T.C

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF SPORT PHYSIOTHERAPY

INVESTIGATION OF THE RELATIONSHIP BETWEEN CORE STABILIZATION, BALANCE, AND AGILITY PARAMETERS IN CROSSFIT ATHLETES

MASTER THESIS

BAŞAK BİÇER, PT

İSTANBUL-2022

T.C

YEDİTEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF SPORT PHYSIOTHERAPY

INVESTIGATION OF THE RELATIONSHIP BETWEEN CORE STABILIZATION, BALANCE, AND AGILITY PARAMETERS IN CROSSFIT ATHLETES

MASTER THESIS

BAŞAK BİÇER, PT

ADVISER

PROF. DR. FERYAL SUBAŞI

İSTANBUL-2022

THESIS APPROVAL FORM

Institute : Yeditepe University Institute of Health Sciences

Programme : Sport Physiotherapy

Title of the Thesis : Investigation of The Relationship Between Core Stabilization, Balance, And Agility Parameters in CrossFit Athletes.

Owner of the Thesis : Başak Biçer

Examination Date : 24.06.2022

This study has been approved as a Master/Doctorate Thesis in regard to content and quality by the Jury.

	Title, Name-Surname (Institution)
Chair of the Jury:	Asst. Prof. Dr. Zuhal Didem Takinacı Sağlık Bilimleri University
Supervisor:	Prof. Dr. Feryal Subaşı Yeditepe University
Member/Examiner:	Asst. Prof. Dr. Çiğdem Yazıcı Mutlu Yeditepe University

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 the Administrative Board of Institute with a decision dated .... and numbered ....

Prof. Dr. Bayram YILMAZ

Director of Institute of Health Sciences

DECLARATION

I hereby declare that this thesis is my 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.

15.07.2022

BAŞAK BİÇER

DEDICATION

I would like to dedicate my thesis to my parents Hatice and Okyay BİÇER for their lifelong support.

BAŞAK BİÇER

ACKNOWLEDGEMENTS

With all the effort made and attention paid to this thesis work has been such devotion to me and my dedicated supervisor Prof. Dr. Feryal Subaşı. She has been sincerely giving and always there whenever I needed her. For the most part it is a great honour to be her master student and I am willing to take our scientific relationship forward.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

%	Symbol of Percentage
3D	Three -Dimensional
A	Anterior
ACSM	American College Sports Medicine
AMRAP	As Many Reps As Possible
ASIS	Anterior Superior Iliac Spine
BMI	Body Mass Index
BFR	Body Fat Percentage
BMM	Body Muscle Mass
BMP	Body Muscle Percentage
BMR	Body Mass Index
BFR	Body Fat Ratio
CF	CrossFit
cm	Centimeter
DEXA	Dual X-Ray Absorptiometry
EMOM	Every Minute on the Minute
F	Female
HICT	High Intensity Cross Training
HIIT	High Intensity Interval Training
HIPT	High Intensity Power Training
LBM	Lean Body Mass
M	Male
NCSS	Number Cruncher Statistical System
n	Number
PF	Pelvic Floor
PL	Posterolateral
PM	Posteromedial
PSIS	Posterior superior iliac spine
RFT	Round for Time

SEBT	Star Excursion Balance Test
TLF	Thoracolumbar Fascia
TrA	Transversus Abdominis
YBT	Y Balance Test
WOD	Work of Day

ABSTRACT

BİÇER, B. (2022). Investigation of the Relationship Between Core Stabilization, Balance, And Agility Parameters in CrossFit Athletes Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, Graduation Thesis. İstanbul.

This study aims to evaluate the relationship between core stabilization, balance, and agility parameters in CrossFit athletes. In addition, the second aim of the study is to examine the variation of this relationship according to gender. For this purpose, 46 CrossFit athletes (F/M 22/24) between the ages of 18-57 who met the inclusion criteria of the study voluntarily participated. After the warm-up period, McGill Core Endurance Tests to assess core stabilization, Y Balance Test for Balance assessment, T Agility Test for Agility assessment, and Body Composition Analysis to assess body fat and muscle percentages were applied to the athletes, respectively. A 5-minute rest period was given between all tests. Number Cruncher Statistical System 2007 program was used for statistical analysis of the data. As a result, a negative correlation was observed between the right-side core endurance and agility levels of CrossFit athletes ($r=-,620$, $p<0,01$). Additionally, a negative correlation was observed between the left side core endurance and agility levels of CrossFit athletes ($r=-,655$, $p<0,01$). A positive correlation was observed between the right leg balance and core stabilization parameters of the athletes ($r=,354$, $p<0.05$). There was found a positive and moderately significant relationship between left leg balance and time to completion (flexor) ($r=,401$, $p<0,01$). There was found a positive and weakly significant relationship between left leg balance and flexion: extension ratio ($r=,323$,$p<0,05$). As a conclusion, core stabilization and agility parameters in CrossFit athletes affect by backward to each other. Accordingly, it means that athletes with better side core endurance finish the t-test faster and has better agility.

Keywords: CrossFit, Y balance, T-agility Test, Core Stabilization

ÖZET

BİÇER, B. (2022). CrossFit Sporcularında Kor Stabilizasyon, Denge ve Çeviklik Parametreleri Arasındaki İlişkinin İncelenmesi. Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Anabilim Dalı, Yüksek Lisans Tezi. İstanbul.

Bu çalışma, CrossFit sporcularında core stabilizasyonu, denge ve çeviklik parametreleri arasındaki ilişkiyi değerlendirmeyi amaçlamaktadır. Ayrıca çalışmanın ikinci amacı, bu ilişkinin cinsiyete göre değişimini incelemektir. Bu amaçla araştırmaya dahil edilme kriterlerini karşılayan 18-57 yaş arası 46 CrossFit sporcusu (K/E 22/24) gönüllü olarak katılmıştır. Isınma periyodundan sonra sporculara sırasıyla core stabilizasyonunu değerlendirmek için McGill Core Endurance Testleri, Dengeyi değerlendirmek için Y Balance Testi, Çevikliği değerlendirmek için T Agility Testi ve vücut yağ ve kas yüzdelerini değerlendirmek için Body Composition Analysis uygulandı. Tüm testler arasında 5 dakika dinlenme süresi verildi. Verilerin istatistiksel analizi için Number Cruncher Statistical System 2007 programı kullanıldı. Sonuç olarak CrossFit sporcularının sağ yan kor dayanıklılık ve çeviklik düzeyleri arasında negatif bir ilişki olduğu görüldü (r=-,620, p<0,01). Ayrıca CrossFit sporcularının sol yan kor enduransı ile çeviklik düzeyleri arasında negatif bir ilişki gözlendi (r=-,655, p<0,01). Sporcuların sağ bacak dengesi ile core stabilizasyon parametreleri arasında pozitif korelasyon gözlendi (r=,354, p<0.05). Sol bacak dengesi ile tamamlanma süresi (fleksör) arasında pozitif ve orta düzeyde anlamlı bir ilişki bulundu (r=,401, p<0,01). Sol bacak dengesi ile fleksiyon:ekstansiyon oranı arasında pozitif yönde ve zayıf düzeyde anlamlı bir ilişki bulundu (r=,323,p<0,05). Sonuç olarak CrossFit sporcularında core stabilizasyon ve çeviklik parametreleri geriye doğru birbirini etkilemektedir. Buna göre, daha iyi yan çekirdek dayanıklılığına sahip sporcuların t-testini daha hızlı bitirdiği ve daha iyi çevikliğe sahip olduğu anlamına gelir.

Anahtar kelimeler: CrossFit, Y denge Testi, T çeviklik Testi, Kor stabilizasyon

1. INTRODUCTION AND PURPOSE

Greg Glassman, a former fitness coach, gymnast, and conditioner, is the founder of CrossFit. In 1995, Greg Glassman opened the first CrossFit Institute. In the beginning, CrossFit is developed for firefighters, military, and police departments. CrossFit was designed to improve perfection in all physical missions (4). It is becoming popular among civil society and athletes (5,6). CrossFit can be defined in many ways. One of the ways is that it includes rapid and ballistic movements but also other training methodologies such as functional training, interval training, or endurance workouts can be a part of it. In short, CrossFit (CF) is a kind of fitness program that is described as high-intensity functional movement training (4). Due to the nature of CrossFit, it includes more than one sport. Running, rowing, swimming, biking and any other type of metabolic conditioning exercises can be examples of it. In addition to this, CF also includes rapid and ballistic movements that are usually in high-intensity exercise programming such as snatch, power clean, jumping, clean, and jerk (7).

CrossFit workouts are designed as a generalized group training that is called Workouts of the Day (WOD). The program of WOD is changed day by day with the CrossFit trainers. The program CF combines a high-intensity functional movement exercise program with interval training methods (4). In this type of exercise program, limited time of rest is given to create strength and endurance. The interval training of CrossFit can be separated into four main training strategies that are TABATA, AMRAP, EMOM, and RFT. The training starts with a specialized warm-up. After that, workouts of the day are practised with little or no rest. As a result of this methodology, CF becomes a combination of weightlifting, cardiovascular and gymnastic types of exercise in a certain limited time (4,8,9).

CrossFit has remarkable benefits for athletes who decided to join. The benefits of CrossFit can be aligned as that; lower body fat percentage (BFP), increased lean body mass (LBM), increased brain-derived neurotrophic factor levels, and improved aerobic and anaerobic capacity (6). CrossFit also has significant physiologic effects on athletes. Nowadays, it becomes more favourable for human beings because of its physical outcomes, taking short time for training, and its variation (4). CrossFit needs some fundamental physical skills. These are flexibility, strength, power, stamina, coordination, speed, agility, balance, and aerobic and anaerobic endurance (4). Balance can be accepted as one of the most important physical skills in CrossFit (6).

Maintaining a certain position during an activity or static position be defined as balance even when the centre of gravity is changed (10). Static balance is the ability to maintain and keep the body’s centre of gravity in the body's base of support while stationary. On the other hand, dynamic balance is described as keeping the body's gravity centre during active movements or switching positions (11). Balance is affected by three different somatosensory outputs which are the vestibular system, vision, and proprioception. Having a proper balance is also related to athletes’ injury levels and life quality. Balance function is affected by sensory outputs but also by the time needed for the processing of cortex and muscle strength (10).

Muscle strength can be described as the ability to create force with muscular units. (4) Core stabilization which is also known as core strengthening or abdominal muscle strengthening is an essential key component of training for athletes. The core includes many large and small muscles which are from the hip, pelvis, abdominal and lumbar regions to achieve stabilization during functional movements (12). When a person starts to activate the core stabilization system efficiently; the requested distribution of forces, optimal control over the body parts, and smoothness of functional movement through the kinetic chain happen as a result of this activation. The most sportive activity needs perfect coordination among the lower and upper limbs. Core stabilization supplies this interaction. It prevents athletes' bodies from moving outside of their base of support. Athletes who have poor core stabilization or poor neuromuscular core control are at risk for lower extremity injuries. In addition, core strength is significant for athletes' performance (1).

The achievement of purposes by fulfilling or exceeding present standards can be accepted as performance. Physiological and psychological parameters of athletes influence their performance. Physiological parameters are muscular endurance, muscle strength, agility, and muscle flexibility. In other respects, psychological parameters are focussing, motivation and enthusiasm. Improvement in sport-specific skills, physiological factors and psychological factors to reach the best ability level in a determined sport type can be also another description of performance (13). Agility is a component of performance; it can be defined as athletes' ability for changing the direction of their movement accurately and rapidly. This component needs quickness which is made from the cognitive and physical ability to react (8).

It is one of the fundamental components of a competitive area. CrossFit also has worldwide and native competitions. The biggest competition is called CrossFit Games. The CrossFit Games are organized annually. As a result of competition "The Fittest on the Earth" is determined (14).

The reason for injuries related to CF usually comes from weightlifting or gymnastic type of movements (5,15). Additionally, a retrospective study in 2018 suggests that the injury risk of CF is lower or comparable to other kinds of training methods (16). The shoulders, lumbar spine, and knees are the most injured body parts in CF (15,17). The musculoskeletal type of injury prevalence is %30.3. There are not much more differences in musculoskeletal injury prevalence between CrossFit and strength training (17). In addition, CrossFit athletes who do not take any regular physiotherapy care and join the CrossFit program more than four days a week are more predisposed to have the musculoskeletal type of injury (18).

Prevention of athletes from musculoskeletal injuries is the main concern of athletes' health care professionals, coaches, and themselves. A study calculated that approximately more than 10.000 people a day look for medical concerns for sports or exercise-related injuries (19). Another study has data from the International Association of Athletics Federation of World Athletics Championships suggests acute non-contact injuries include 13% and overload injuries 44% of competition injuries (19).

Therefore, agility, balance, and core stabilization are important components of sportive activity. Research about sport-specific agility, balance, or core stabilization can be found in the literature (20). However, none of them gives information about the relationship between these physical skill parameters of CrossFit Athletes. Despite the literature research, the relationships between athletes' agility, balance, and core muscle activation are still less clarified.

The investigation of these parameters' relationship gains importance to prevent athletes from injuries and give proper training and rehabilitation baseline. In this study, we aim to define the correlation between agility, balance, and core muscle endurance in CrossFit athletes. The second aim of the study contributes information about gender differences between core stabilization, balance, and agility parameters in CrossFit athletes.

Hypothesis 0 (H0):

There is no correlation between core stabilization, balance, and agility parameters in CrossFit athletes.

Hypothesis 1 (H1):

There is a correlation between core stabilization, balance and agility parameters in CrossFit athletes.

Hypothesis 0 (H0)

There is no gender difference between core stabilization, balance and agility parameters in CrossFit athletes.

Hypothesis 1 (H1):

There is a gender difference between core stabilization, balance and agility parameters in CrossFit athletes.

2. LITERATURE REVIEW

2.1. CrossFit or High-intensity Cross-Training

CrossFit can be defined in many ways. One of the ways is that it includes rapid and ballistic movements but also other training methodologies such as functional training, interval training, or endurance workouts can be a part of it. Additionally, CrossFit is a kind of fitness program that includes a variant combination of weightlifting, gymnastic type, and cardiovascular exercise at a high-intensity level with a short resting time (5,16,15,21).

High-intensity Cross Training can be referred to as a kind of training that exceeds the anaerobic threshold in a short to moderate time. In this training type rest is limited and recovery is almost not allowed. This method aims to use physiological systems more than its requirement (22). High-intensity cross-training (HICT) or "CrossFit" combines continuously variable exercise intensities and multiple exercise methodologies. A characteristic of HICT workouts occurs from the putting in order of multiple exercises consecutively with no or limited rest time. Additionally, workouts which resistance-based exercises performed at a high percentage of maximum until failure is a consistent aerobic stimulus. CrossFit or HICT practices have been stated to be extremely vigorous, because of their range of 90% maximal heart rate (HRmax) and 80% maximal oxygen uptake (VO2max) (23).

2.2. History of CrossFit

Greg Glassman, a former fitness coach, gymnast, and conditioner, is the founder of CrossFit. In 1995, Greg Glassman opened the first CrossFit box. CrossFit was designed to improve perfection in all physical missions. In the beginning, CrossFit is developed for firefighters, military and police departments. After the increasing number of attendances, the founder stars group lessons that are called WOD (Workout of the Day) (4). Since its foundation, more than 10.000 affiliated gyms on worldwide participating in growth and have been sponsored by Reebok in recent years (24,25,26,27,28). In 2007 the first CrossFit Games was made as a worldwide competition. The champion of this competition is called the fittest of the world (27).

2.3. Training strategies of CrossFit

The training model in CrossFit allows for a wide variance of mode, exercise, metabolic pathway, rest, intensity, sets, and repetitions (4). In the CrossFit-based exercise program, high-intensity training is experienced in multi-joint movements (29).

CrossFit has a generalized group training that is called Workouts of the Day (WOD). The program of WOD is changed day by day with the CrossFit trainers. Every WOD session takes approximately 1 hour. Specialized warm-up is added to the WOD program before training time (28). The type of training on WOD can show variation. The WOD can focus on strength, metabolic conditioning, weightlifting, or mixed. The duration of WOD also varies according to the type of exercise (4,8,27).

There are four different types of interval training in CrossFit. These are AMRAP (As Many Reps As Possible), EMOM (Every Minute on the Minute), RFT (Round for Time), and TABATA (4).

2.3.1. AMRAP (As Many Reps as Possible)

AMRAP training model can be explained with maximum repetitions or rounds in each period. In this model training the time completion was fixed, so the model focused on time. Therefore, the size volume and intensity of the workout vary (8).

2.3.2. EMOM (Every Minute on the Minute)

EMOM training model is explained by performing a certain movement in one minute within a certain total time interval. In this model after performing a certain movement the remaining time from one minute is accepted for rest time. Therefore, the athlete who finishes earlier rests more (8).

2.3.3. RFT (Round for Time)

RFT training model can be explained as a certain number of rounds being practised in the shortest time. The round for time method is focused on the duty. The aim of RFT is the complete the duty as soon as possible. In this model, the number of rounds and repetitions were determined. Therefore, the main load does not vary (8).

2.3.4. TABATA

TABATA training model is created by Doctor Izumi TABATA. The model is a kind of intermittent training with 20 sec. workout time and 10 sec. rest period. This model focus on the improvement of anaerobic capacity (9).

2.4. Weightlifting and Olympic lifting training on CrossFit

The weightlifting methodology in CrossFit focuses on producing power and control capacity on external forces. Olympic lifting can be classified as snatch and clean and jerk. For a master ship on this kind of lift, athletes should be developed on some kind of specialized movements such as the deadlift, split jerk, squat, and power clean. As a result of Olympic lifting training, the greatest amount of muscle fibre is forced in a certain sequence (4). In addition, Olympic weightlifting has an impact on health including cardiovascular fitness capacity, improving blood pressure, and glycaemic control (30).

2.5. Interval training on CrossFit

Interval training has an opportunity to improve the cardiovascular system without the training side effects such as strength, speed, or power loss. In interval training, the training program is formed with work and rest periods. Interval training is composed according to the metabolic pathway to create energy such as phosphagen, glycolytic or oxidative system (4).

Table 2.1: Primary Energy Systems (4).

	SPRINT	MID DISTANCE	DISTANCE
Primary Energy System	Phosphagen	Glycolytic	Oxidative
Duration of Work (in sec.)	10-30	30-120	120-300
Duration of Recovery (in sec.)	30-90	60-240	120-300
Load: Recovery Ratio	1:3	1:2	1:1
Repetitions	25-30	10-20	3-5

CrossFit training is taken into consideration as a selection for high-intensity interval training (HIIT). HIIT needs advanced level techniques through the greatest timed training repetitions with inadequate recovery time between sets. The most critical point is that there is an overload training with insufficient rest time (24). There are four different types of interval training in CrossFit. These are AMRAP (As Many Reps As Possible), EMOM (Every Minute on the Minute), RFT (Round for Time) and TABATA (4).

2.6. Gymnastic and calisthenic training on CrossFit

Gymnastics can be classified into three groups that are acrobatic, rhythmic, and artistic gymnastics (31). Gymnastics is a type of exercise that needs flexibility, agility, coordination, and balance. The most important part of gymnastic training is maintaining body control while the movement. The calisthenic movements such as rope climbs, pull-ups, dips, handstand walking, and push-ups need a balance between the core and extremities (4). In a way of gymnastics on CrossFit is considered as bodyweight movements such as pull up, push up and, handstand walking. As a result of this, a remarkable strength achievement can be produced without external forces (31).

2.7. Outcome from CrossFit

CrossFit has a significant effect on physical fitness parameters which are aerobic fitness, body composition, muscular fitness, and flexibility (21,32). Barfield et all. found that CrossFit participants' have %6 greater aerobic fitness and %22 greater upper body muscle endurance improvements than traditional fitness participants. In 2013 Smit et al. Made over 10-week CrossFit-based high-intensity power training (HIPT) and found that % the 3.7 body fat percentage dropped and a %1.8 VO2max level increased (33). Because of rapid growth opportunities, CrossFit becomes a new fitness option for many athletes.

2.8. Physiology of CrossFit

CrossFit training provides the athletes with a neuroendocrine adaptation by hormones and neurological changes. Hormones such as testosterone growth hormone or insulin-like growth hormone have a significant increase in athletes. The training protocols are known to have an increasing effect on these hormones, mimicking the hormonal alteration that is obtained by exogenous hormonal therapy without any kind of side effects of its. (4) CrossFit training has an effect that improves the performance of athletes who train well due to the high-intensity interval training period (34).

The advanced CrossFit athletes have a lower body fat percentage, greater muscle morphology characteristics, peak aerobic capacity, greater lean body mass,3 min cycling performance, and isometric strength characteristics according to recreational CrossFit athletes and physically active controls. However, there are no differences between recreational CrossFit athletes and physically active controls in resting metabolic rate and hormone concentrations according to blood samples of testosterone, cortisol, and insulin-like growth factor-1 (35).

Aerobic power, lower body endurance, upper body pull endurance and general muscle strength can be improved by CrossFit training. Especially, compared with traditional resistance training CrossFit has a greater effect on upper body muscle endurance. However, it is not valid for lower body anaerobic power according to a six-week training period (36).

CrossFit has also another physiologic benefit on the brain-derived neurotrophic factor which is responsible for the growth and production of neurons in three months of training athletes. However, the irisin hormone that affects the regulation of glucose homeostasis, spending of energy, BMI, and insulin resistance has no significant change during this time (37).

CrossFit training for two consecutive days influences anti-inflammatory cytokines reduction while no change in muscular power (24).

Every kind of CrossFit training can be a different physiological result. For this reason, the differences between benchmarks of CrossFit were investigated. According to Toledo et all. Different training strategies on CrossFit have no change on heart rate or sexes. However, rated perceived exertion, lactate levels, and training load have remarkable variation depending on training types (38).

In 2017, Drake et all. found that 4 weeks of CrossFit template program has an increasing effect on the inflammatory status and decreasing effect on mood state of performance. However, there was no change in strength, endurance, and body composition (27).

In 2019 Podersso et all. Found that 6 months of CrossFit template program for 5 days on week has resulted in an elevation of testosterone levels especially in men, decreasing cortisol levels, especially in a woman. In another study in 2019, Tibana et al. found that more than 6 months of trained CrossFit athletes have elevated testosterone land immunoglobulin A levels. However, there is no change in cortisol levels (27).

Testosterone and cortisol have an acute elevation effect after training and maintain this elevation from 30 to 60 min. it turns to normal levels after days of training. For a compression of the CrossFit-related over-trained syndrome athletes, healthy men, and physically inactive controls, testosterone levels showed greater in healthy men than over-trained athletes (39).

2.9. Sport-Specific Parameters of CrossFit

CrossFit guides explain the physical abilities of CrossFit with nine parameters. These are flexibility, strength, power, stamina, coordination, speed, agility, balance, and cardiorespiratory endurance (4).

2.9.1. Flexibility

It can be referred to as an ability for using a maximum range of motion in the specific joint(s) for a movement. To accomplish a movement properly, athletes need a total range of motion (4). The agonist-antagonist muscle relationship should be proper for using the total range of motion. While the agonist muscle is contracted, the antagonist muscle should relax and permit the agonist muscle to accomplish the range of motion. Flexibility gains importance at this point. The level of flexibility can be changed by race, age, and gender (40).

2.9.2. Strength

Muscle strength can be described as the ability to create force with muscular units. Especially, the gymnastics and weightlifting types of movements need proper core strength with specific muscle strength (4). Barfield et all. found that CrossFit participants' have %6 greater aerobic fitness and %22 greater upper body muscle endurance improvements than traditional fitness participants (33).

2.9.3. Power

Power is the ability to create a maximum force for a movement (4). Power can also be accepted as a combination of muscle strength and speed (time to accomplish a movement). As explained, CrossFit training is accomplished in a limited period with little or no rest. Therefore, Power is one of the main abilities of CrossFit athletes (14).

2.9.4. Stamina

Stamina is also known as endurance. It is an ability to create and sustain energy through training. Additionally, it is also a resistance to fatigue through workouts. (4,14)

2.9.5. Speed and Coordination

Coordination can be defined as a combination of movement patterns of the body while performing a specific movement. It is important for the training that includes a multi-joint movement. Speed can be defined as the accomplishment of a movement in the shortest time. It gains importance, especially in the competitive area (4,14).

2.9.6. Agility

Agility is a component of performance; it can be defined as athletes' ability for changing the direction of their movement accurately and rapidly. This component needs quickness which is made from the cognitive and physical ability to react. It is one of the fundamental components of a competitive area (8,4).

2.9.7. Balance

According to ACSM, balance performance can be accepted as a physical fitness component. Two kinds of balance are static and dynamic balance. Static balance is the ability to maintain and keep the body’s centre of gravity in the body’s base of support while stationary. On the other hand, dynamic balance is described as keeping the body's gravity centre during active movements or switching positions (11). Both static and dynamic balance has importance in sportive activity to maintain dynamic postural control on sport-specific tasks in competitive and non-competitive areas (41).

2.9.8. Cardiorespiratory endurance

Cardiorespiratory endurance is the capacity for oxygen delivery to muscles through training. The athletes who have good cardiorespiratory endurance can train longer and feel the fatigue later. This ability is also important for the prevention of chronic illnesses such as heart disease and obesity (42). The improvement in cardiorespiratory endurance can positively affect CrossFit athletes' respiratory ability and blood circulation physiology (40).

2.10. Core Stability

Core stabilization which is also known as core strengthening or abdominal muscle strengthening is an essential key component of training for athletes (43,12). The meaning of the core includes many large and small muscles which are from the hip, pelvis, abdominal and lumbar regions to achieve stabilization during functional movements (12). The lumbopelvic hip complex is created by the core. The top of this cylinder complex is the diaphragm, and the bottom of it is the pelvic floor muscles. this cylinder is completed with posterior muscles and abdominal muscles (44).

2.10.1. Functional anatomy and core muscles

There is two anatomical subdivision of the core muscle group that is known as the Global system and Local system. The global system refers to quadratus lumborum, external obliques, rectus abdominis and erector spine which are prime movers of the trunk. It also transfers the body load among the pelvis and thorax. The local system includes internal obliques, multifidus, pelvic floor muscles, and transverse abdominals. However, the psoas muscle is left out by this system, it is accepted in the global system. This system controls the single vertebral segments as a result of this control it produces stabilization (1).

According to Bergmark, Core muscles are separated local and global. The local muscles are the transversus abdominis and multifidus. On the other hand, global muscles are the erector spine, Rectus abdominis, Quadratus lumborum, internal oblique and external oblique (45).

Table 2.2: Core Muscles Classification (45).

Local Muscles		**Global Muscles**
Primer Muscles	**Seconder Muscles**	Rectus Abdominis Obliques externus (lateral) Psoas Major Erector spine İliocostalis (thoracic part)
Transversus Abdominis Multifidus	Internal Oblique External Oblique Pelvic Floor Muscles İliocostalis Longissimus Quadratus Lumborum Diaphragm	

In 2001, Mottram and Comerford create another model for core muscle classification. This model focus on muscle function. (46) This classification has three-part which are local stabilizers, global stabilizers, and global mobilizers. The main difference between stabilizers and mobilizers is eccentric and concentric work. While stabilizers control movement eccentrically, mobilizers control it concentrically. Additionally, mobilizers have a role as shock absorbers (44). The load taken from the core area increases from local stabilizers to global stabilizers and global stabilizers to global mobilizers (46).

Table 2.3: Functional Classification of Core Muscles (46).

Local Stabiliser	**Global Stabiliser**	**Global Mobiliser**
Transversus Abdominis	Oblique Abdominals	Rectus Abdominis
Multifidus	Spinalis	İliocostalis
Psoas Major	Gluteus Medius	Piriformis

2.10.1.1. Abdominal Muscles

Transversus abdominis, Rectus abdominis, Obliques internus and externus abdominis are formed the abdominal musculature of body (47). Internal obliques are flexing and turn the body's abdominal area to the same side. On the other hand, external obliques flex and turn the body's abdominal area to the opposite side (48). TrA has a great attachment to the abdominal area. Its origin includes thoracolumbar fascia, last six costa, crista iliaca and some part of inguinal ligament (49). Its insertion can be accepted as Linea alba. Transversus abdominis (TrA) is the deepest muscle of the core region that generates the starting action of trunk muscles. TrA has also an important role in the primary stabilization of trunk load on the spine (50,51,52). TrA can also be accepted as a belt for the abdominal area through its fibre’s horizontal position. For stabilizing the core area, TrA and multifidus muscle contraction starts 30ms earlier than upper extremity movements and 110 ms earlier than lower extremity movements. To create an intra-abdominal pressure that is needed for a solid spine internal oblique and TrA are contracted together and make a hoop by the thoracolumbar fascia. On the other hand, the movement that needs anterior pelvic tilt is controlled by external obliques muscles (53).

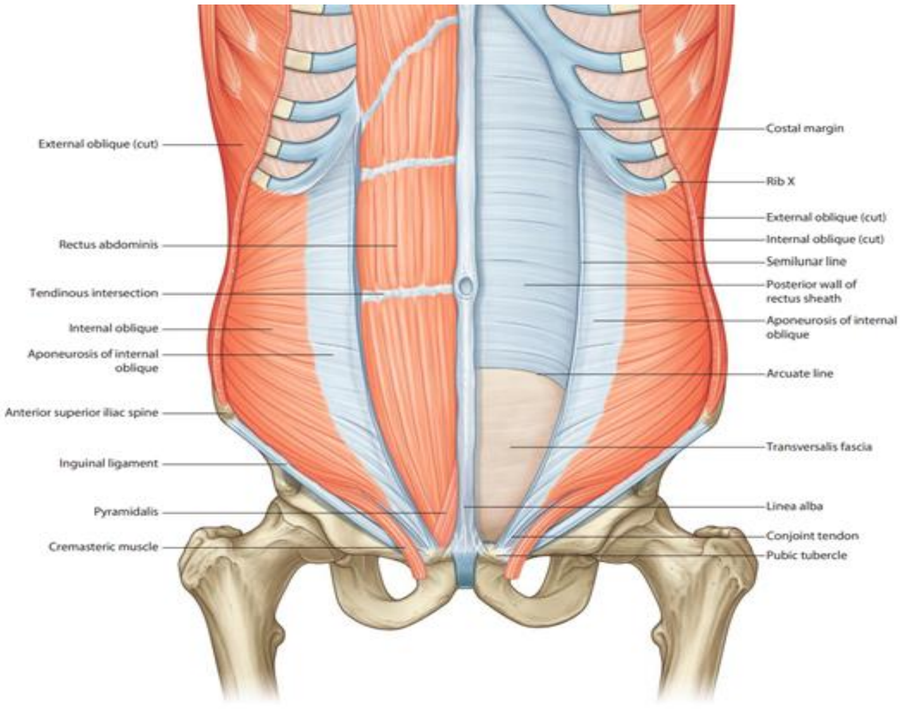


Figure 2.1: Anterior view of abdominal muscles (48).

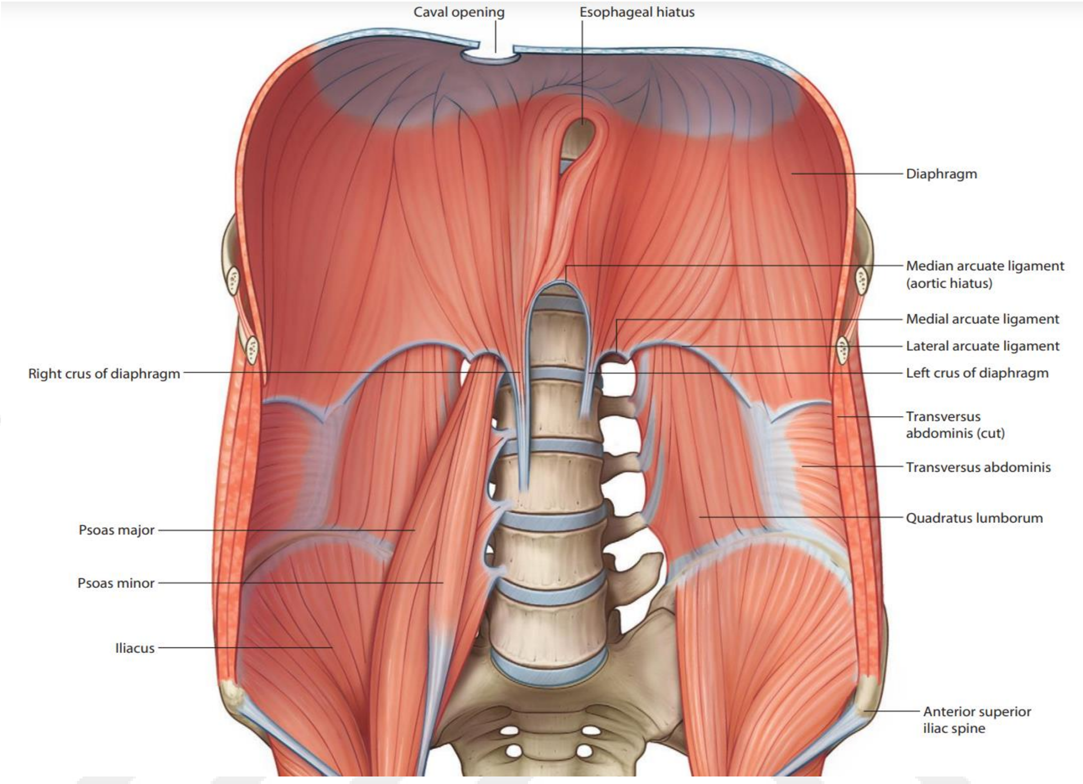


Figure 2.2: Posterior view of abdominal muscles (48).

2.10.1.2. Posterior Paraspinal Muscles and Quadratus lumborum

Paraspinal muscles known as the erector spine that is formed by longissimus and iliocostalis muscle. These muscles extend from the thoracic area to the lumbar region. The thoracic extension of these muscles creates an extensor torque while lumbar extension creates posterior shearing force during stabilization of anterior shear of the lumbar region. the posterior muscles are completed with the quadratus lumborum. The Quadratus lumborum muscle acts as a stabilizer for movement with an isometric contraction. In addition to this, it adjusts the stability according to the amount of tension according to load (47).

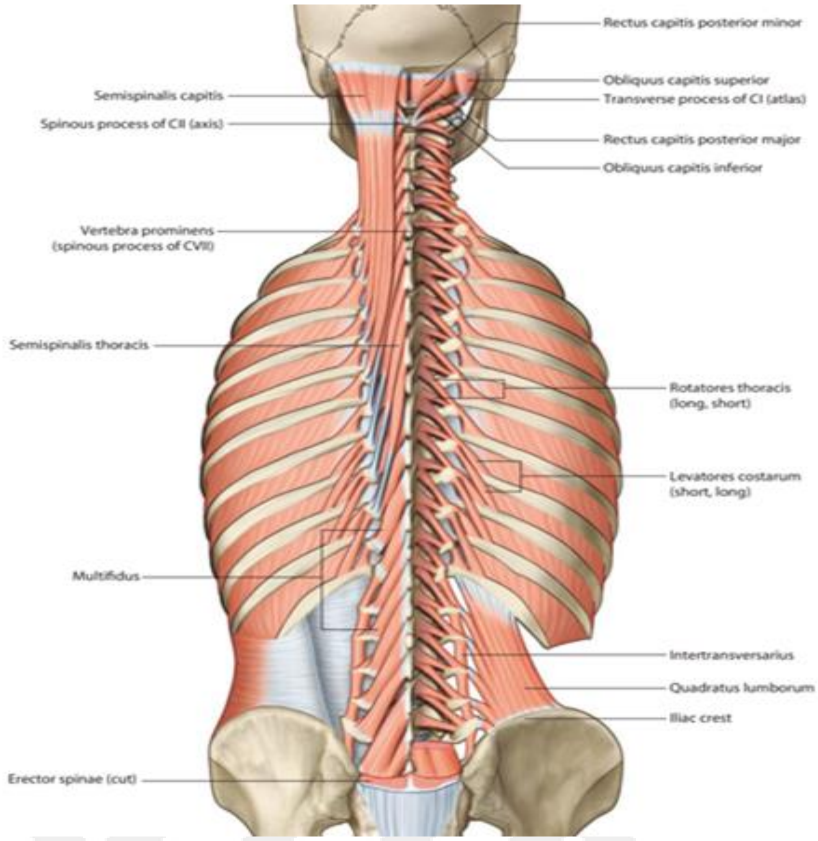


Figure 2.3: Paraspinal muscles and Quadratus Lumborum (48).

2.10.1.3. Diaphragm

The diaphragm is a dome-shaped muscle that is made by the right and left hemidiaphragm. Its rib attachment starts from the xiphoid process and lasts six ribs. The right hemidiaphragm extends through the anterior surfaces of the L1-L3 vertebrae and the left hemidiaphragm extends through the anterior surface of the L1-L2 vertebrae. The core area can be considered as a hoop. The base of this hoop is pelvic floor muscles, the anterior aspect of this hoop is abdominal muscles, and the posterior aspect of its paraspinal muscles and thoracolumbar fascia. In addition to this, for creating a whole cylinder, the diaphragm muscle settles down to the top of the core area. When human inspire diaphragm contracts and move to the abdominal area. This movement creates pressure on the pelvic floor and eccentric contraction of abdominal muscles. At the end of this process, intra-abdominal pressure has occurred. (53,54).

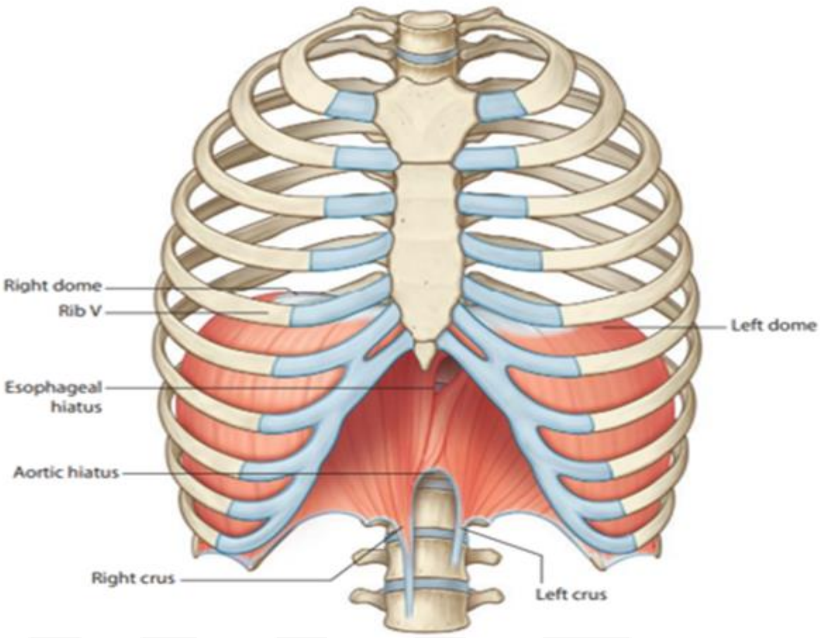


Figure 2.4: Diaphragm (48).

The importance of the diaphragm is creating spinal stability in the core area by increasing the intra-abdominal pressure (53,54). anterior aspect the of this hoop is the abdominal muscles and the posterior aspect of its paraspinal muscles and thoracolumbar fascia. In addition to this, for creating a whole cylinder, the diaphragm muscle settles down to the top of the core area. When human inspire diaphragm contracts and move to the abdominal area. This movement creates pressure on pelvic floor and eccentric contraction of abdominal muscles. At the end of this process intra-abdominal pressure is occurred (54). The importance of the diaphragm is creating spinal stability in the core area by increasing the intra-abdominal pressure (53,54).

2.10.1.4. Muscles of Pelvic Floor

The pelvic floor (PF) is composed of three layers that are superficial, intermediate, and deep layers. The superficial layer of PF is composed of superficial transverse perineal muscles, bulbospongiosus, external anal sphincter, and ischiocavernosus. The intermediate layer of PF is composed of deep transverse Perine and intrinsic urethral sphincter. In addition to this, compressor urethra and urethrovaginal sphincter are included in the woman. The deep layer of PF is composed of the deep levator ani, coccygeus, puborectalis, iliococcygeus, and pubococcygeus Pelvic floor muscles are the only muscles that carry the loads transversally (55). In a movement like carrying a load or head and shoulder flexion type of functional activities need contraction from both abdominal muscles and pelvic floor muscles (52). As a result of this, the coactivation between pelvic floor muscles and TrA contraction through a movement has occurred (53,56).

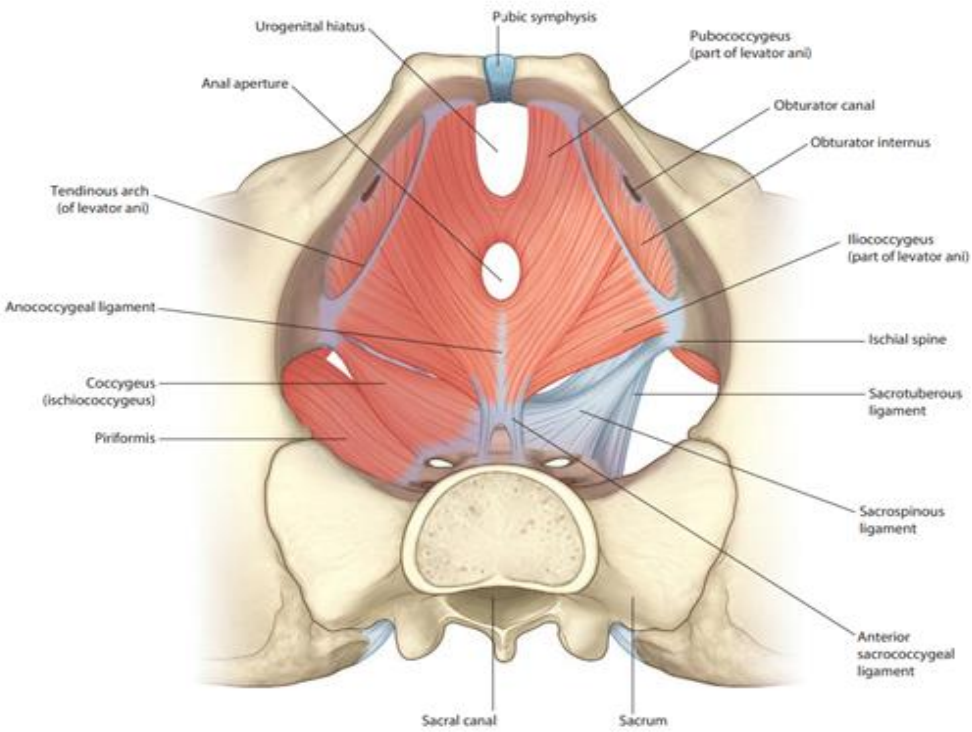


Figure 2.5: Superior view of pelvic floor muscles (48).

2.10.1.5. Thoracolumbar Fascia

Thoracolumbar fascia can be accepted as a huge attachment point for the core area. It acts as a separator between paraspinal muscles and abdominal muscles. There are two models for explaining thoracolumbar fascia (53).

One of the models is the two-layer model. According to the two-layered model, TLF is occurred by anterior and posterior layers.

The anterior layers of TLF have a role in separating quadratus lumborum and paraspinal muscles and it acts as an aponeurosis. On the other hand, the posterior layer has occurred of two sheets that are deep and superficial lamina. The deep lamina covers paraspinal muscles. On the other hand, the superficial lamina is created by latissimus dorsi aponeurosis and is associated with the deep lamina in the lumbar area. In addition to this, the fascia that is placed in front of the quadratus lumborum can be accepted as an extension of the transversal fascia.

Another model for thoracolumbar fascia is the three-layered model. Three-layered models are quite similar to the two-layer model. The posterior layer of the three-layered model is the same as the two-layered model. However, the anterior layer of the two-layer model is accepted as the middle layer for the three-layered model. Additionally, the anterior layer of their layered model is considered a Transversalis fascia from the abdominal wall (51).

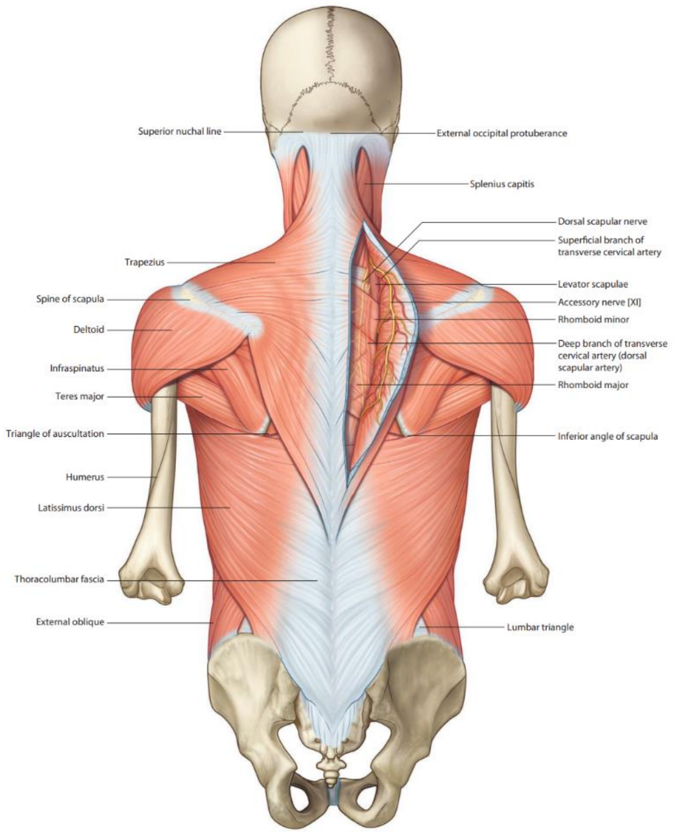


Figure 2.6: Thoracolumbar fascia and Latissimus Dorsi (48).

The Thoracolumbar fascia can transfer loads between the trunk and limbs in a movement (53). Additionally, it has the ability for taking nociceptive and proprioceptive innervation. When the multifidus contracts and increased its tone, the Thoracolumbar fascia creates a link and make the tension between two PSIS (Posterior superior iliac spine). This tension leads to force closure on the sacroiliac joint and stabilizes the pelvis of the body (51).

2.10.2. Core stabilization effect on activity

Most of the sportive activities need perfect coordination among the lower and upper limbs. Core stabilization supplies this interaction. In addition, core strength is significant for athletes' performance. When a person starts to activate the core stabilization system efficiently; the requested distribution of forces, optimal control over the body parts and smoothness of functional movement through the kinetic chain are happening because of this activation. It prevents athletes' bodies from moving outside of their base of support (57). Athletes who have poor core stabilization or poor neuromuscular core control are at risk for lower extremity injuries (58). Okada et all explained important correlations between core muscle strength and performance of sprinting, throwing, and jumping in young healthy individuals (1).

More than 6-week core strength training improves balance ability and core endurance however agility might not improve at the same time (59). In contrast to this result in 2018 Bashir et all suggest that core training increases the dynamic balance activity and agility (2,3). Additionally, a core training program gives the athletes an improvement in their proprioceptive activity and athletic performance (60,61).

In 2018 Szafraniec et all. showed that core stability training also has some acute effect on athletes' mediolateral body balance ability. Its acute effect starts after 30 min of training and lasts at least one day (62).

2.10.3. Core biomechanism

The core region of the body has occurred of three different areas which made the coxo-lumbopelvic complex. Local and global muscles around this complex create a valuable link between the upper and lower extremity. The core has a key role to create distal mobility by providing proximal stability for movement (63).

Spinal stability system is made of three subdivisions that are active subsystem, passive subsystem, and control subsystem (44,64).

The first subdivision is the active subsystem. The active subsystem can be referred to as spinal muscles and tendons to create a movement, carry the load on the trunk, and provide maintenance on spinal tissues. The second subdivision is the passive subsystem. The passive subsystem can be referred to as the spinal column that includes articulations, ligaments, vertebras, and joint capsules. The main importance of this subsystem is to provide information from mechanoreceptors to the neural control system. The third subdivision is the neural subsystem. The control subsystem or neural subsystem provides information from different transporters such as tension on tendons or ligaments according to an external force. The most important part of this subsystem is providing maintenance on core stabilization by efferent and afferent stimuli (44,64).

For a generation, a movement on the trunk, firstly body activates the transverses abdominis muscles. This activation takes 29 ms for the upper limb and 109 ms for the lower limb (50). The main purpose of the core is explained as the generation of postural stability on movements. Therefore, when the body is moved, muscles are activated and create a force on the trunk. This force has equal value and opposite direction of the force needed to move (50,63).

All processes of activation CNS activate the muscles by providing an efferent stimulus. This stimulation made tension in the thoracolumbar fascia activate muscles responsible for trunk stabilization and activation (50).

2.10.4. Core Stabilization and CrossFit relationship

For the Olympic lifts to be successful, force transfer is required from the centre of the body to the distal muscle groups. To achieve this situation, core strength is required with the potential to provide the necessary power (4,57).

2.11. Balance

Balance is a term to explain postural control in both dynamic and static situations (65). To maintain balance sensorimotor activation is needed. This activation gives information from the proprioceptive, visual, and vestibular systems which are responsible for motion, equilibrium, and spatial orientation. This sensorimotor output is integrated into the cerebellum, cerebral cortex, and brainstem. After that, vestibula-ocular reflex, and motor impulses such as postural adjustment have occurred as motor output. Finally, balance is maintained (66).

The most crucial factors that affect balance ability are sensory information from somatosensory, vestibular, and visual systems. Additionally, the motor response of the body has a significant effect on balance ability by influencing ROM, coordination, and strength (67). To sum up, both sensory and motor systems affect the balance performance of human beings (67).

2.11.1. Static Balance

Static stability is related to the equilibrium in pristine conditions such as calm stops (17). Static balance is the ability to maintain a support base with minimal movement (68). In conclusion, static balance is the ability to maintain and keep the body's centre of gravity in the body's base of support while stationary (11,69).

2.11.2. Dynamic balance

Dynamic balance is keeping equilibrium during any movement or recovering it by changing body position as soon as possible (69). While creating velocity on the multi-directional movements, for body needs to maintain the movement with proper techniques (68).

2.11.3. Balance effect on sportive activity

According to ACSM, balance performance can be accepted as a physical fitness component. Both static and dynamic balance has importance in sportive activity to maintain dynamic postural control on sport-specific tasks in competitive and non-competitive areas (41). Specific functional tasks, sport-related performance, and postural control mechanisms of athletes also show improvements by balance training (70). Minimum 2 weeks of balance training has a statistically significant gain in athletes’ balance performance. Additionally, balance training has a preventative effect on the reduction of ankle injuries which is common in sportive areas (41). Therefore, balance and postural control training for athletes usually prefer to protect athletes from injuries (67).

In the comparison of swimmers, gymnasts, and soccer players' dynamic balance ability, gymnasts have a greater ability on dynamic balance than the other two groups (69). Another research about sports-specific balance showed that weightlifters are less influenced by sway trajectory while performing a barbell squat with higher weights than an amateur bodybuilder (71).

2.11.4. Relationship between balance and CrossFit

The movement in CrossFit needs a proper balance to complete the movement with true techniques. Balance during the workout is important for athletic performance. The most important part of the balance in CrossFit is frontal plane movements such as kipping pull-ups, handstands, snatch, etc. The frontal plane separates the body anterior to posterior. The balance on the frontal plane focus on the transfer of load on midfoot. As a result of this, the balance on the frontal plane provides decreasing on injury risk by decreasing movement errors (72).

2.12. Agility

Agility is a component of performance; it can be defined as athletes' ability for changing the direction of their movement accurately and rapidly (73,74,75,76). However, agility is more than the speed of changing direction. It needs quickness which is made from cognitive and physical ability to react especially for sudden movements. (74). This ability gives athletes a chance to prepare and performs their best. Therefore, agility is a key component of the sportive activity (75).

2.12.1. Parameters of agility

Determinants of agility are classified into three components: the first one is the cognitive factors. Cognitive factors include decision-making and speed accuracy according to visual scan, anticipation, pattern recognition, and knowledge situation.

The second one is the physical factors that include core strength, straight speed, leg muscles' power, strength, and reactive strength.

The third one is the technical factors that include posture, foot placement, and adjustment of step acceleration (77).

2.12.2. Relationship between CrossFit and Agility ability

Agility has a complex ability that includes decision-making, speed, power, and stability. The most important part of increasing agility is neuromuscular adaptation to the performing tasks (76). Speed and quickness are the significant parameters for agility (78). The CrossFit training methods are high-intensity training models that are usually against the time such as RFT. In addition to this agility provides the decreasing transition time from a certain movement to another. Therefore, agility becomes a valuable ability for CrossFit training methods (4).

3. MATERIAL AND METHODS

3.1. Subjects

The sample of the study consists of athletes who specialized in CrossFit in İstanbul, Turkey, and interested in CrossFit for more than 6 months. CrossFit athletes who were training in CrossFit 34 institution from February to April were included in the study.

G-Power 3.1 program is used for the determination of sample size. As a result of this determination, the sample size is found 46 active CrossFit athletes. 22 female and 24 male athletes were included in the study. The range of age in the study group is 18-57. The study is designed as a Cross-Sectional study.

3.1.1. Inclusion Criteria

Participating to study in a voluntarily.

Being between18 -65 years old

Attending and continuing CrossFit-based sportive activity more than 6 month.

Attending and continuing CrossFit training minimum three times a week.

3.1.2. Exclusion Criteria

Having any kind of injury in last three months.

Having any kind of surgery that consists of the knee in last 6 months.

Having physical and/or mental disability

Having visual, hearing and/or verbal impairments.

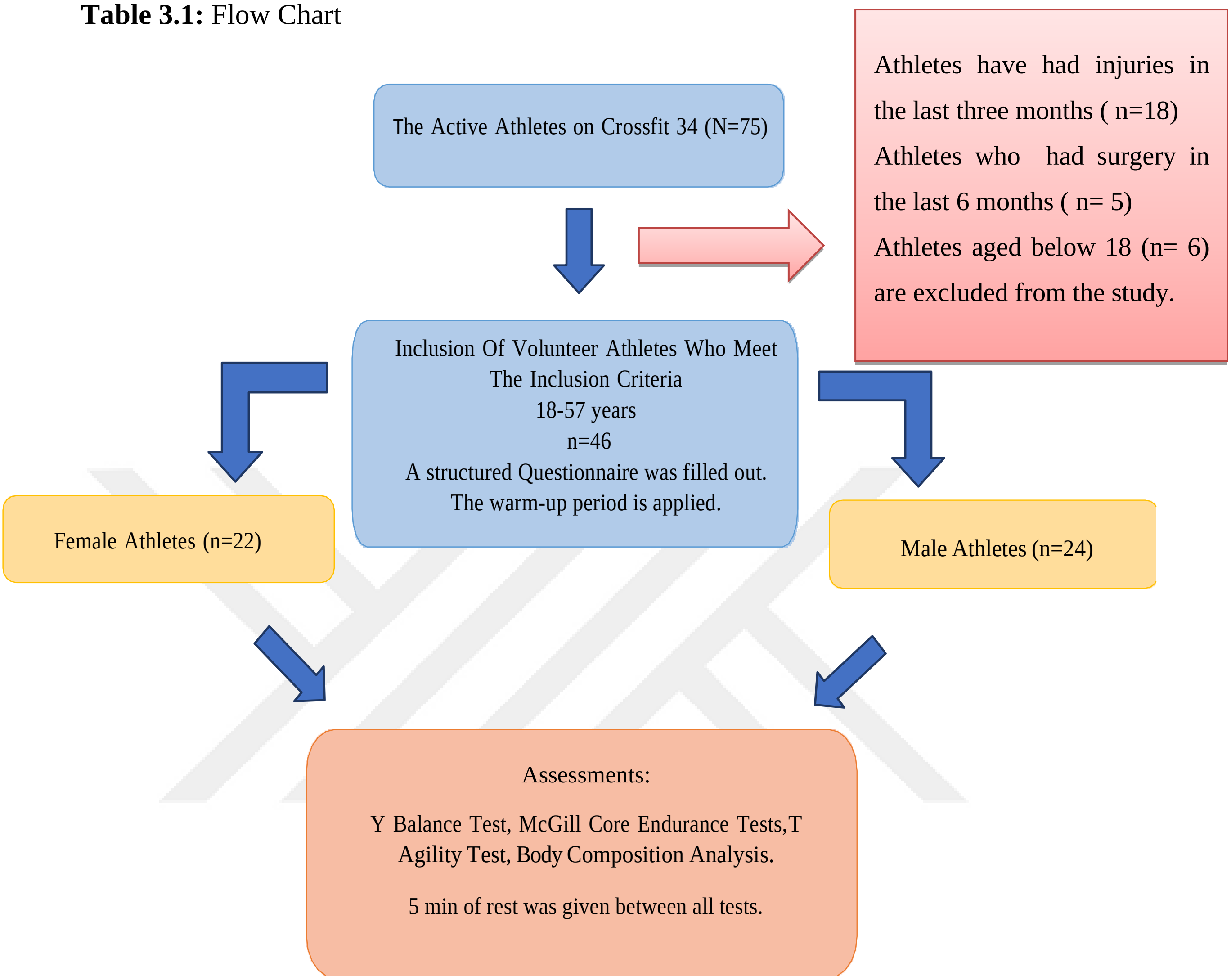
Being sedentary.

Being on a treatment about any musculoskeletal injury.

Having any chronical disease.

Participants with BMI higher than 30 and correlated with unhealthy body mass evaluation.

Table 3.1: Flow Chart



3.1.3. Study Protocol

The research was designed as a descriptive cross-sectional study. Thus, the cause-effect relationship between the variables will be investigated together at the same time at a certain time. In cross-sectional studies, analytical results representing the researched population can be reached, since the population is studied on a selected sample group. Due to this feature, a descriptive cross-sectional study design was created. The use of this study design will provide cause-effect analyses between core stabilization, balance, and agility, and obtain scientific results that represent the researched population. The universe of the study consists of approximately 15 CrossFit halls in Istanbul, within the scope of our specialized knowledge of CrossFit. Many CrossFit Gyms are not open regularly during the study due to the Covid-19 pandemic.

For this the reason, our work will take place at CrossFit 34 institution, which we have access to, which specializes in CrossFit in Istanbul and is the first CrossFit gym in Turkey. Athletes who have been doing CrossFit training in this institution for more than 6 months (minimum 3 days a week) constitute the sample of our study.

Table 3.2: Study Protocol

Study Protocol
5-minute Warm-up (jogging in place, jumping jack, mountain climber, burpee)
3-5 minutes Y Balance Test (Posterolateral-Posteromedial-Anterior)
5-minute rest after Y balance test
McGill Core Endurance Tests (Trunk Flexion+Trunk Extension+ Right/Left Side Planks) 5-minute rests between endurance tests
5-minute rest after endurance test
T Agility test
Body Composition Analyses

There are some examples of daily workouts/WODs of athletes on CrossFit 34 institution.

DAY 1

<u>32 Min – 8 Round/Set</u>

1.Min:200 M Run

2.Min:10 Calorie Assault Bike

3.Min:18 Dumbbell Power Snatch(22.5Kg-12,5Kg) (R1-L2)

4.Min: Rest

DAY 2

<u>6 Round/Set-</u> Cap Time:30 Min

5 repetition Clean Jerks (Weighted between; 60Kg-45Kg)

10 repetition Back Squat (Weighted between; 60Kg-45Kg)

15 repetition Chest to Bar Pull-Up

DAY 3

<u>12 Min, 6 Round/Set</u>

1.Round :5 repetition front squat (with %75 load)

2.Round:3 repetition front squat (with %80 load)

3 Round:1 repetition front squat (with%85-%90 load)

4.Round:8 repetition front squat (with%70-%75 load)

5.Round:8 repetition front squat (with%70-%75 load)

6.Round:8 repetition front squat (with%70-%75 load)

-Then-

<u>Cap Time:23 Min</u>

42 repetition Wall-Ball (load between 9Kg-6Kg)

21 repetition Burpee Lateral Jump

15 repetition Overhead Squat (load between 40Kg-25Kg)

30 repetition Wall-Ball (load between 9Kg-6Kg)

15 repetition Burpee Lateral Jump

12 repetition Overhead Squat (load between 40Kg-25Kg)

18 repetition Wall-Ball (load between 9Kg-6Kg)

9 repetition Burpee Lateral Jump

9 repetition Overhead Squat (load between 40Kg-25Kg)

All subjects were included in the Structured Questionnaire which is adapted for the Turkish population. Before examining the subjects, they were asked to fill in this questionnaire that contained administrative data, medical history, and current health. After this questionnaire, the investigators explained the purpose and content of the testing series, after which the participants were asked to sign informed consent forms. Subsequently, each participant performed a 5 min warm-up.

3.2. EVALUATION

3.2.1. Structured Questionnaire

The structured questionnaire prepared by researchers was applied to face-to-face interviews. The first part of the questionnaire included age, gender, height, body weight, body mass index, hand and foot dominance, chronic diseases, and surgery experience of volunteers. The second part of the questionnaire included sport-related factors which are the position and type of athletic performance, frequency, and time of exercise sessions, the matches per week, and any injuries in the last 3 months.

3.2.2. Y Balance Test

Y balance test is also known as the Modified Star Excursion Test (4). Y balance is a reliable and validated modification of the star excursion balance test (SEBT). It might be accepted as a functional screening tool for a variety of purposes. It can help to understand the stability of lower extremities, progression of the rehabilitation process, remaining deficits after injury, and differentiate the risk level of injury. Additionally, it gives us information about the combination of strength, flexibility, balance, and coordination (79).

The test includes 3 different directions which are anterior, posterolateral, and posteromedial. These three directions are important in their predictiveness for available injury risks. 4 cm or more differences between lower extremities in the anterior direction are accepted as 2.5 times increased non-contact injury risk for an individual. Additionally, more than % 94 variation of compound reach score is accepted as a rising risk for injury (80). Subjects must remove their shoes. After doing this, they must stand behind the red line and wait for instructions in the middle platform.

Figure 3.1: Y Balance Test Diagram (81)

The test should be performed in the following order:

1. Right Front
2. Right Posteromedial
3. Right Posterolateral

When the hands are placed firmly on the hips, the subject should touch the tip of the finger with his right foot as far as possible and instruct them to return to the upright position. They should then repeat this with the same foot for three successful accesses in total. Subjects can proceed in the next test direction (i.e., posteromedial) after 3 successful accesses with each foot. The test manager must record the access distance of each attempt to calculate the y- balance test (YBT) composite score. The test manager takes the average of these three values and obtains a score (81).

In the final validity and reliability study conducted in 2021, the Y balance test (YBT) showed excellent validity and reliability for both asymptomatic and chronic low back pain participant groups, with ICC coefficients ranging from 0.99 to 1.0 for YBT scores (82).

Y balance test results are taken as a right and left stance anterior, posteromedial, and posterolateral score. For the understanding of total limb balance, the composite scores right and left are used (83).

Composite Score (%cm): ((Anterior+posteromedial+posterolateral)/ (3*Limb Length) *100) (83).

3.2.3. Agility T Test

It is used for determining the change of direction ability of athletes. It is a multidirectional test that includes sprinting forward, backpedalling, and lateral shuffling. This test is accepted as a valid tool for understanding athletes' multidirectional speed, power, and lower extremity ability of chancing direction. Additionally, agility T-test has greatest correlation with 5m,10m sprint and shuffling speed (r = -0.83, r = -0.92, r = - 0.75) (84).

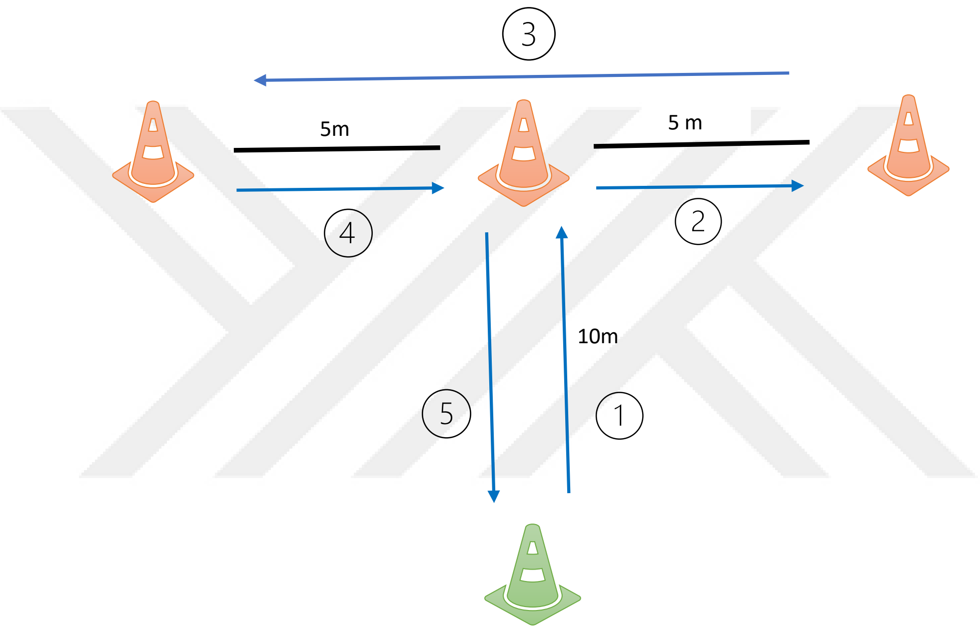


Figure 3.2: T agility test diagram (85).

The T-test can give us valid and reliable information about leg power, speed, and agility which are important for recreational activities and sports performance (85). For applying the testing protocol, tape for the measure, marking cones, and a time is needed as equipment. Before the test, the testing procedure is explained to athletes by the physiotherapist. The test was set up by a physiotherapist with four cones as shown in the diagram. The athlete is placed at cone A, after starting command of the timer, the athlete sprints to cone B and touches the cone B base with his/her right hand. Then, turning and shuffling to it and again touching cone C base with his/her left hand. After that, directly turn and shuffle to cone D and touches its base with his/her right hand. Finally, athletes shuffle sideways to cone B touch its base with/her left hand, and backpedal to cone A. The physiotherapist stopped the timer when the athlete passes the cone A (85).

For the T-test, when power, leg speed, and agility were examined, the in-class reliability (ICC) was found to be 0.98 in 3 trials. Calculation of partial correlations, and evaluation of the validity of the T-test as a measure of agility, leg strength, and leg speed, together with the result obtained, seems to be quite reliable (86). In addition to measuring a combination of components such as leg speed, leg strength, and agility, it has been demonstrated to be useful to distinguish between low and high sports participation (87).

Table 3.3: The normative values of the T-test are explained in below as tables (85).

Deciles	90	80	70	60	50	40	30	20	10
Female T test (s)	10.69	10.92	11.48	11.99	12.34	12.73	13.24	13.69	14.23
Male T test (s)	9.45	9.82	10.06	10.22	10.44	10.64	10.99	11.22	11.69

Table 3.4: The Quartiles of T test are explained in below as tables (85).

Quartiles	75	50	25
Female	11.23	12.34	13.41
Male	9.95	10.44	11.07

3.2.4. Core Stabilization Abdominal Muscle Strength Assessment

There were different kinds of tests for assessing the core stabilization such as single-leg squat, supine or unilateral hip bridge endurance test, side bridge endurance test, prone bridge endurance test, trunk stability test, front abdominal power test, McGill protocol with isometric flexor-extensor-side bride endurance, plank to fatigue and alternative trunk stability push-up test, etc. (12).

In this examination, McGill protocol was used. It's a fast, validated, and simple field-based screening test. McGill protocol help to understand the endurance ability of core muscles which are also known as torso stabilizers. In this protocol, four different tests are combined to assess the isometric endurance capability of the torso. Tests might be aligned as trunk flexor test, left lateral trunk endurance test, trunk extensor test, and right lateral trunk endurance test. A timer is needed as equipment for this test protocol. The test aims to measure the time holding the torso in a stable position with given isometric activity. Minimum 5 minutes of rest is needed between four tests (88,23).

As a result of the evaluations, the trunk flexor endurance test with an ICC value of 0.80, the right trunk endurance test with an ICC value of 0.88, and the left trunk endurance test with an ICC value of 0.89 show high reliability. The extensor endurance test has a remarkably high-reliability score with an ICC value of 0.90 (23).

Table 3.5: Intra- rater reliability (ICC Scores) for core stabilization tests (23).

Intra- rater reliability (ICC Scores) for core stabilization tests			
Trunk flexor test	Trunk extensor test	Right trunk endurance test	Left trunk endurance test
0.80	0.90	0.88	0.89

3.2.4.1. Trunk Flexor Test

The test begins in the seated position. Knees and hips are positioned in 90-degree flexion. Additionally, arms are crossed on the front of the body, and fingers touch the opposite shoulder. Athletes are bent on a board that has 60 degrees decline and athletes' head is in a neutral position (89).

For starting the test, the board is pulled 10 cm back and athletes try to keep his/her stable position as long as possible (89). Timer begins with pulling off the board and holding times are recorded.

3.2.4.2. Trunk Extensor Test

Athletes are positioned on the end of a bench. Iliac crest of athletes touches the edge of the bench. Additionally, arms are crossed on the front of the body, and fingers touch the opposite shoulder. The athletes are stabilized from their lower extremities and positioned on the upper border of the iliac crest (90). Athletes try to keep the horizontal position as long as possible (89,91). Timer begins with coming to the proper position when athletes are ready and holding times are recorded (89,91).

3.2.4.3. Right and Left Lateral Trunk Endurance Test

Athletes start on a mat with a full side bridge position. Legs are extended and the lateral side of the foot touches the ground. Shoulders and arms are aligned as shown. The opposite arm is positioned on the side of the body. Athletes try to keep their hips in upward and their spine in a neutral position as long as possible. In this test, hip shifting is accepted as a test failure. Test repeats for opposite sides and time are recorded. (92,88,91). The normative value of these tests is explained below in tables.

,

Table 3.6: Normative percentile data in trunk flexor test (89).

Percentile	**19-29**		**30-39**		**40-49**		**50-59**		**60+**	
Female/Male	F	M	F	M	F	M	F	M	F	M
75	67	57	50	57	35	60	50	50	25	35
50	41	40	30	36	25	33	31	39	12	18
25	26	30	18	20	14	17	18	22	0	9

Table 3.7: Normative percentile data in trunk extensor test (89).

Percentile	19-29		30-39		40-49		50-59		60+	
Female/Male	F	M	F	M	F	M	F	M	F	M
75	173	187	150	190	116	180	160	135	76	199
50	99	124	106	119	63	120	88	98	23	79
25	56	67	65	59	40	49	31	44	10	34

Table 3.8: Normative percentile data in right lateral side bridge (93).

Percentile	19-29		30-39		40-49		50-59	
Female/Male	F	M	F	M	F	M	F	M
75	83.75	131.25	62.5	105.0	67.0	107.25	46.5	76.75
50	56.0	86.0	49.0	70.0	38.0	70.0	21.5	53.0
25	35.0	39.5	27.0	57.0	10.5	38.5	11.48	29.25

Table 3.9: Normative percentile data in left lateral side bridge (93).

Percentile	19-29		30-39		40-49		50-59	
Female/Male	F	M	F	M	F	M	F	M
75	84.5	128.0	69.5	100.5	69.5	102.0	58.5	81.5
50	58.6	82.0	50.0	74.0	36.0	70.5	18.5	48.0
25	28.8	57.5	27.0	52.5	69.5	38.25	13.13	25.75

3.2.5. Body Composition Analysis

Body composition analysis will be evaluated with a 3D body scanning system. The 3D body scanning system takes a 3D image of the person. It interactively measures and calculates whole body anthropometric measurements, fat ratio, lean muscle mass, BMI/BMR value, waist/hip ratio, and daily calorie needs. It provides regular monitoring of values with advanced reporting and statistical tools. The device creates an incredibly detailed and three-dimensional map of the body with the help of infrared rays. These maps allow you to reach your body's fat and muscle ratios, and lean body mass results with much greater precision compared to other measurement methods (94).

It uses 3D volume and anthropometric measurements to determine body composition. This form of measurement is a derivative of the underwater weighing method. In both forms of measurement, the main purpose is to find the body volume and to determine the body fat ratio with statistical data and calculations based on this.

During the evaluation, participants are asked to remove their shoes and socks. Then, they are asked to stand still with the arms at 30 degrees of abduction and the feet shoulder-width apart. Images are obtained by drawing circles around the participant with the device. As a result of the images obtained, the device performs its reporting and analysis (94).

In the reliability study conducted for body composition analysis measurement with 3D scanning, its in-class reliability was demonstrated to be excellent with an ICC coefficient of 0.993 (95).

When compared to DEXA (Dual X-Ray Absorptiometry), which is accepted as the gold standard for Body Composition analysis, three-dimensional body composition analysis measurements (body fat ratio, lean mass, and fat mass) can be considered valid (96,97).

3.3. Statistical Analysis

G-Power 3.1 program is used for the determination of sample size. The total sample size found using the G-Power program is n=46 with an effect size of 0.5, a power of 95%, and a margin of error of 0.05, based on the percentage measurement values of the methods to be studied.

NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program was used for statistical analysis. While evaluating the study data, descriptive statistical methods (Mean, Standard Deviation, Median, Frequency, Ratio, Minimum, Maximum), as well as the distribution of the data, were evaluated with the Shapiro-Wilk Test.

Kruskall-Wallis’s test in the comparison of quantitative data of three or more groups; Mann-Whitney U test was used for comparison of two groups. Spearman's correlation analysis was used to determine the relationship between quantitative data. Significance was evaluated at $p<0.05$ levels

4. RESULTS

The study included 46 CrossFit athletes who were actively training at CrossFit 34 Gym, Istanbul. The physical features (age, weight, height, body mass index (BMI), and body fat percentage of athletes are shown in Table 4.1.

Table 4.1: Physical Features of Participants

	mean ± SD	**Min-Max (Median)**
Age (Year)	29,65±8,49	17-57 (28)
Height (m)	1,74±0,08	1,6-1,98 (1,75)
Weight (kg)	71,96±12,93	51-105 (70)
BMI (kg/m2)	23,63±3,04	17,6-29,9 (24,05)
BFP (%)	21,47±2,88	16,2-28,6 (21,1)
RLL(m)	84,8±6,21	71-97 (86)

Data expressed as mean±standard deviation. BMI: Body mass index, BFP: Body fat percentage, RLL: Right Limb Length.

Table 4.2: Distribution of Gender

		N	**%**
Gender	Female	22	47.8
	Male	24	52.2

N: sample size, %= percentage

While 47.8% (n=22) of the participants were female, 52.2% (n=24) were male.

Table 4.3: Distribution of Smoking Status

		N	%
Smoking Status	I don't drink	29	63.0
	I quit	9	19.6
	I am drinking	8	17.4

N: sample size, %= percentage

%63 of the participants, (n=29) said they don't drink, 19.6% (n=9) quit, and 17.4% (n=8) said they smoke.

Table 4.4: Distribution of Previous Medical Operation Status

		N	%
Previous Medical Operation Status	Yes	11	23.9
	No	35	76.1

N: sample size, %= percentage

While 23.9% (n=11) of the participants had a previous medical operation, 76.1% (n=35) did not.

Table 4.5: Distribution of training frequency

		N	%
Frequency of Doing Sports	2-3 Times a Week	6	13.0
	4-5 Times a Week	32	69.6
	Everyday	8	17.4

N: sample size, %= percentage

13% (n=6) of the participants do sports 2-3 times a week, 69.6% (n=32) do sports 4-5 times a week and 17.4% (n=8) every day

Table 4.6: Distribution of Time of joining CrossFit

		N	**%**
Time to start sports	6-12 months	8	17.4
	1-3 years	16	34.8
	more than 3 years	22	47.8

N: sample size, %= percentage

17.4% (n=8) of the participants began the CrossFit for 6-12 months, 34.8% (n=16) of them were 1-3 years, and 47.8% (n=22) more than 3 years ago started the sport.

Table 4.7: Distribution of Sport Duration

		N	**%**
Sports Time	30-60 Min.	28	60.9
	More than 60 Minutes	18	39.1

N: sample size, %= percentage

While 60.9% (n=28) of the participants do sports between 30-60 minutes, 39.1% (n=18) of them do sports for more than 60 minutes.

Table 4.8: Distribution of previous Injury Status

		N	**%**
Injury Status	Yes	12	26.1
	No	34	73.9

N: sample size, %= percentage

While 26.1% (n=12) of the participants had an injury, 73.9% (n=34) did not.

Table 4.9: Distribution by T-Test Ranking

		N	%
T-Test Ranking	Modarate	23	50.0
	Poor	23	50.0

N: sample size, %= percentage

50% of the participants, (n=23) t-test ranking was moderate, while 50% (n=23) were poor.

Table 4.10: Comparison of Y Balance test variables according to gender

			Male	**Female**	**P value**
Y BALANCE TEST	A	Right	73,98±8,15	69,03±8,09	0,117
		Left	73,58±11,16	69,08±8,24	0,031*
	PM	Right	86,47±13,51	81,36±9,71	0,275
		Left	87,68±15,72	83,16±13,91	0,559
	PL	Right	83,52±16,91	79,38±14,39	0,537
		Left	89,65±17,01	78,74±18,74	0,090
	Composite Right	-	90,65±20,9	92,39±9,03	0,509
	Composite Left	-	92,37±21,44	92,62±11,71	0,567

Mann Whitney U Test ***p<0,05** ****p<0,01** Data expressed as mean ± standard deviation SD: Standard deviation. n: number of participants. A=Anterior, PM=Posteromedial, PL=Posterolateral cm: centimetres

Table 4.11: Comparison of T test performance norms according to gender

	Gender	**n**	**mean±SD**	**Min-Max (Median)**	***p***
T-Test Performance Norms	Female	22	13,96±2,08	11,53-17,95 (14,28)	***0,001*****
	Male	24	11,63±0,99	10,46-14,01 (11,36)	

Mann Whitney U Test *p<0,05 **p<0,01 Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants.

The age value of the average group was found to be lower than the poor group (p=0.001; p<0.05). According to the t-test ranking, the body fat ratio value does not show a statistically significant difference (p>0.05). It was found statistically significant that the right-side time to completion value (right trunk endurance test value) of the average group was higher than the weak group (p=0.001; p<0.05). The left side time to completion value (left trunk endurance test value) of the average group was found to be higher than the poor group (p=0.001; p<0.05). The side-bridge (each side): extension ratio value of the average group was found to be higher than the poor group (p=0.001; p<0.05). The composite right value does not show a statistically significant difference according to the t-test ranking (p>0.05). The composite left value does not show a statistically significant difference according to the t-test ranking (p>0.05)

Table 4.12: Comparison of Demographic Measurements according to gender

	Gender	**n**	**mean ±SD**	**Min-Max (Median)**	***p***
Age	Female	22	30±10,13	17-57 (27,5)	0,921
	Male	24	29,33±6,86	19-46 (28)	
BMI	Female	22	22,24±3,14	17,6-29 (21,65)	***0,003***
	Male	24	24,9±2,35	20,5-29,9 (24,6)	
BFR	Female	22	20,35±2,87	16,2-28,6 (19,8)	***0,005***
	Male	24	22,5±2,52	18,7-28,2 (21,95)	
Right Limb Length	Female	22	83,09±4,41	71-94 (81)	***0,008***
	Male	24	86,38±7,23	71-97 (88)	
Body Muscle Mass	Female	22	48,09±6,05	39,5±63,4	***0,001***
	Male	24	59,3±6,12	49,7±75,8	
Body Muscle Percentage	Female	22	75,31±2,49	68,4±79,1	***0,028****
	Male	24	73,95±2,45	68,3±79	

***p<0,05** ****p<0,01** Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants, P: P-value.

Table 4.13 Comparison of McGill Tests according to gender

	Gender	n	mean±SD	Min-Max (Median)	*p*
Time to completion (flexor)	Female	22	137,73±82,54	55-302 (104)	0,956
	Male	24	122,71±71,39	61-352 (106)	
Right side time to completion	Female	22	63,82±27,09	22-131 (65,5)	***0,004*****
	Male	24	103,63±45,81	30-208 (120)	
Left side time to completion	Female	22	67,86±29,69	25-124 (75)	***0,009*****
	Male	24	101,58±48,73	38-220 (120)	
Time to completion (extensor)	Female	22	135,95±61,8	62-291 (120)	0,912
	Male	24	129,46±50,64	63-273 (128,5)	
Flexion: extension ratio	Female	22	0,95±0,26	0,38-1,43 (0,98)	0,168
	Male	24	0,88±0,25	0,46-1,46 (0,95)	
Right-side bridge left-side bridge ratio	Female	22	0,96±0,24	0,03-1,4 (0,99)	0,232
	Male	24	1,05±0,17	0,78-1,45 (1)	
Side-bridge (each side): extension ratio	Female	22	0,5±0,23	0,14-0,85 (0,44)	***0,005*****
	Male	24	0,73±0,23	0,09-1,03 (0,68)	

***p<0,05** ****p<0,01** Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants, P: P-value.

Table 4.14 Comparison of Y Balance Tests according to gender

	Gender	n	mean ±SD	Min-Max (Median)	*p*
Stance Left Anterior	Female	22	69,08±8,24	55,6-95,3 (68)	***0,031****
	Male	24	73,58±11,16	54-95,3 (72,45)	
Stance Left Posteromedial	Female	22	83,16±13,91	52-101,6 (87,3)	0,559
	Male	24	87,68±15,72	61,6-110,6 (85,6)	
Stance Left Posterolateral	Female	22	78,74±18,74	31-107 (83)	0,090
	Male	24	89,65±17,01	56,3-114 (88,15)	
Stance Right Anterior	Female	22	69,03±8,09	55-90 (71,3)	0,117
	Male	24	73,98±8,15	62-90 (73)	
Stance Right Posteromedial	Female	22	81,36±9,71	53-98,3 (82,3)	0,275
	Male	24	86,47±13,51	55,3-105 (89,5)	
Stance Right Posterolateral	Female	22	79,38±14,39	36-91,6 (84,6)	0,537
	Male	24	83,52±16,91	46-105 (84,3)	
Composite Right	Female	22	92,39±9,03	57,03-100 (94,65)	0,509
	Male	24	90,65±20,9	0,94-109,4 (95,65)	
Composite Left	Female	22	92,62±11,71	59,5-105,1 (97,4)	0,567
	Male	24	92,37±21,44	1,02-119,5 (96,5)	

***p<0,05 **p<0,01** Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants, P: P-value.

Age value does not show a statistically significant difference according to gender (p>0.05). The lower body mass index value of the female group compared to the male group was found to be statistically significant (p=0.001; p<0.05). It was found statistically significant that the body fat ratio of the female group was lower than that of the male group (respectively, p=0.001; p<0.05). It was found statistically significant that the right limb length value of the female group was lower than that of the male group (respectively, p=0.001; p<0.05).

The stance left anterior value of the female group was found to be lower than the male group (respectively, p=0.001; p<0.05). The stance left posteromedial value did not show a statistically significant difference according to gender (p>0.05). The stance left posterolateral value did not show a statistically significant difference according to gender (p>0.05). The stance right anterior value did not show a statistically significant difference according to gender (p>0.05). There was no statistically significant difference in stance right posteromedial value according to gender (p>0.05).

The stance right posterolateral value did not show a statistically significant difference according to gender (p>0.05). The composite right value did not show a statistically significant difference according to gender (p>0.05). The Composite left value does not show a statistically significant difference according to gender (p>0.05).

The time to completion (flexor) value did not show a statistically significant difference according to gender (p>0.05). It was found statistically significant that the right-side time to completion value of the female group was lower than that of the male group (respectively, p=0.001; p<0.05). It was found statistically significant that the left side time to completion value of the female group was lower than that of the male group (respectively, p=0.001; p<0.05).

The time to completion (extensor) value does not show a statistically significant difference according to gender (p>0.05). Flexion: extension ratio value does not show a statistically significant difference according to gender (p>0.05). The right-side bridge: left-side bridge ratio value did not show a statistically significant difference according to gender (p>0.05). The fact that the side-bridge (each side): extension ratio value of the female group was lower than the male group was found to be statistically significant (respectively, p=0.001; p<0.05). The t-test performance norms value of the female group was found to be higher than the male group (respectively, p=0.001; p<0.05).

Table 4.15: Correlation Analyses

		1	2	3	4	5	6	7	8	9	10	11	12
1. Age	r	1											
	p	.											
2. BMI	r	0,059	1										
	p	,696	.										
3. BFR	r	0,196	,860**	1									
	p	,193	,000	.									
4. Right Limb Length	r	0,214	0,265	,349*	1								
	p	,153	,075	,017	.								
5. Composite Right	r	,172	-,039	-0,039	0,046	1							
	p	,252	,799	,794	,764	.							
6. Composite Left	r	-0,056	0,057	0,051	0,172	,782**	1						
	p	,709	,708	,736	,252	,000	.						
7. Time to completion (flexor)	r	0,088	-0,256	-0,242	0,107	0,234	,401**	1,000					
	p	0,561	0,086	0,105	0,48	,118	,006	.					
8. Right side time to completion	r	,034	0,022	-0,008	0,129	-0,063	0,042	,478**	1				
	p	,821	,885	,959	,392	,675	,784	,001	.				
9. Left side time to completion	r	0,009	-,058	-,035	0,072	-,083	0,032	,459**	,947**	1			
	p	,950	,702	,819	,636	,584	,832	,001	,000	.			
10. Time to completion (extensor)	r	,317*	-0,229	-0,21	,114	0	0,27	,672**	,427**	,416**	1		
	p	,032	,126	,161	,452	0,282	,070	,000	,003	,004	.		
11. Flexion:entension ratio	r	,170	-0,153	-0,123	,051	,354*	,323*	,652**	0,017	-0,02	0,063	1	
	p	,260	,311	,415	,736	,016	0,029	,000	,909	,894	,678	.	
12. T-test performance norms	r	,338*	-0,257	-0,184	-0,059	-0,099	-0,192	-0,037	-,620**	-,655**	0,068	0,244	1
	p	,021	,084	,220	,697	,515	,202	,809	,000	0	,653	,102	.

There is a positive and weakly significant relationship between age and time to completion (extensor) (r=.317, p<0.05). There is a positive and weakly significant relationship between age and t-test performance norms (r=,338, p<0,05). There is no statistically significant relationship between age and body mass index, body fat percentage, right limb length, composite right, composite left, time to completion (flexor), right side time to completion, left side time to completion, and flexion: extension ratio (p>0,05).

There is a positive and highly significant relationship between body mass index and body fat ratio (r=,860, p<0,01). There is no statistically significant relationship between body mass index and right limb length, composite right, composite left, time to completion (flexor), right side time to completion, left side time to completion, time to completion (extensor), flexion: extension ratio and t-test performance norms (p>0,05).

There is a positive and weakly significant relationship between body fat percentage and right limb length (r=,349, p<0,05). There is no statistically significant relationship between body fat percentage and composite right, composite left, time to completion (flexor), right side time to completion, left side time to completion, time to completion (extensor), flexion: extension ratio, and t-test performance norms (p>0,05).

There is no statistically significant relationship between right limb length and composite right, composite left, time to completion (flexor), right side time to completion, left side time to completion, time to completion (extensor), flexion: extension ratio, and t-test performance norms (p>0,05).

There is a positive and highly significant relationship between composite right and composite left (r=,782, p<0,01). There is a positive and weakly significant relationship between composite right and flexion: extension ratio (r=,354, p<0,05). There is no statistically significant relationship between Composite right and time to completion (flexor), right side time to completion, left side time to completion, time to completion (extensor), and t-test performance norms (p>0,05).

There is a positive and moderately significant relationship between Composite left and time to completion (flexor) (r=,401, p<0,01). There is a positive and weakly significant relationship between Composite left and flexion: extension ratio (r=,323, p<0,05). There is no statistically significant relationship between Composite left and right-side time to completion, left-side time to completion, time to completion (extensor) and t-test performance norms (p>0,05).

There is a positive and moderately significant relationship between time to completion (flexor) and right-side time to completion (r=,478, p<0,01). There is a positive and moderately significant relationship between time to completion (flexor) and left side time to completion (r=,459, p<0,01). There is a positive and highly significant relationship between time to completion (flexor) and time to completion (extensor) (r=,672, p<0.01). There is a positive and highly significant relationship between time to completion (flexor) and flexion: extension ratio (r=,652, p<0,01). There is no statistically significant relationship between time to completion (flexor) and t-test performance norms (p>0.05).

There is a positive and highly significant relationship between right side time to completion and left side time to completion (r=,947, p<0,01). There is a positive and moderately significant relationship between right side time to completion and time to completion (extensor) (r=,427, p<0.01). There is a negative and highly significant relationship between right side time to completion and t-test performance norms (r=,620, p<0,01). There is no statistically significant relationship between right side time to completion and flexion: extension ratio (p>0.05).

There is a positive and moderately significant relationship between left side time to completion and time to completion (extensor) (r=,416, p<0,01). There is a negative and highly significant relationship between left side time to completion and t-test performance norms (r=-,655, p<0,01). There is no statistically significant relationship between left side time to completion and flexion: extension ratio (p>0.05).

There is no statistically significant relationship between time to completion (extensor) and flexion: extension ratio and t-test performance norms (p>0.05) There is no statistically significant relationship between flexion: extension ratio and t-test performance norms (p>0,05)

5. DISCUSSION

Our study aims to define the correlation between agility, balance, and core muscle endurance in CrossFit athletes. The second aim of the study contributes information about gender differences between core stabilization, balance, and agility parameters in CrossFit athletes. For this purpose, CrossFit athletes were assessed with McGill Core Endurance Tests, Y Balance Test, T Agility Test, and Body Composition Analysis.

In our study, The T agility tests of the athletes were examined in four main parameters which are poor, average, good, and excellent; half of the athletes showed an average level of agility and half a poor level of agility (Table 4.9). Any of the CrossFit athletes included in the study were not show good or excellent agility on T-test scores (Table 4.9). It was found significant that the age of the athletes who achieved average success in agility parameters was younger than those who achieved a poor level of success. Agility needs a lot of parameters such as power, stability, velocity, and change of direction ability (74,75). In CrossFit, training movements are usually on the frontal and sagittal plane such as snatch, clean and jerk, pull up or push up. Athletes are usually trained with certain movements that do not need rotational directional change (72). This might be the reason for the average and poor level of agility results. For clarification of this opinion, an additional agility examination is needed.

The side bridge endurance tests contract the muscles on side of the core area. These muscles primarily focus on absorbing load and creating rotational force (48). As we explained before, the T agility test needs a great change of direction ability (74). In our study, it was observed that CrossFit athletes with moderate agility levels had higher side bridge endurance test scores than the poor agility level athletes. Additionally, it was observed that the side bridge endurance: extension ratio of the athletes with average agility level were higher than the poor group. Based on this information, it is observed that the agility level of CrossFit athletes has a relationship with the core endurance levels. Santos et all. investigated the relationship between core stabilization and agility with healthy inactive participants. The study showed that there is no significant effect of core stability on agility. (98) Another study on Lacrosse players also supports the findings about the relationship between core stability and agility. The study investigated core stability, balance and agility. They found no significant relationship between them. In our study, there is a negative correlation between right and left side core endurance and the t-test performance scores. It means that athletes with better side core endurance finish the t-test faster. On the other hand, there is no significant correlation between flexor-extensor endurance parameters and agility (Table 4.13). The differences in the results between our study and literature might be related to sport type and participants' activity levels.

In 2016, a study investigated the relationship between core stability, dynamic balance and jump performance in soccer players. They found that core stability has no significant effect on dynamic balance in soccer players (100). Another study on 100 military soldiers investigated the relationship between core stability and static balance. The study found an effect of core stability on static balance (101). As we explained before, CrossFit was designed for the military at the beginning. It means that the participants of the study might have an athletic baseline as CrossFit athletes have. The similarity of results between the article and our study might be related to this reason. In our study, the composite right score has a positive and poor correlation with the flexion: extension ratio. Additionally, there is a positive and moderate correlation between composite left score and flexor endurance. There is a positive and weakly significant relationship between composite left and flexion: extension ratio. However, there is no significant correlation between the other core endurance parameters and the composite right and left score. Although we explain that total balance and core stability parameters are not significantly related to each other, there is a partial relationship between balance and core stability in our study. Therefore, the relationship between core and balance in CrossFit players still needs additional information to clarify.

In 2017 Celik et all. made a research about the balance effect on agility in soccer players. They found no significant effect of balance scores on agility (102). On the other hand, a study in 2021 also investigated the relationship of balance and agility in trained soccer players. Y balance and T agility tests were applied in the study like our study. They found a significant relationship with strong negative correlation (103). Although the test parameters are similar to the article, our results have differences. These differences might be related with the sport type. In our study, Composite right and left scores which are total balance parameters did not have a significant relationship with the agility level of the of athletes. In this case, no significant correlation is observed between balance and agility levels in CrossFit athletes (Table 4.13).

In 2016, the relationship between BFP and agility, reaction time and speed on male football players are investigated. Skinfold calliper, 50m dash test, 6×10 meters shuttle run, and reaction time was evaluated (104). Our study is supported by the research's results. The study found no significant relationship between BFR and agility. In our study, the body fat ratios of the athletes also did not have a significant effect on the agility test. Furthermore, the study shows that there is no correlation between BFR and balance and core endurance, (Table 4.13).

When the results were examined by gender, it was observed that the body fat ratios of female athletes were lower than male athletes. Additionally, female CrossFit athletes have a higher body muscle percentage. The comparison of these two composition analyses shows that gender has an effect on body composition in CrossFit athletes. In 2020, the researchers compare the balance between genders of CrossFit athletes with the Y Balance Test, 52 CrossFit athletes who trained on CrossFit for more than 6 months are included in the study. There was no significant difference in individual reach directions, but significantly more men had a composite right reach score of less than 89.6% compared to women (99). This study supports our findings about the gender comparison on balance. When the Y balance test parameters according to gender were examined in our study, no significant difference was observed in all other parameters except the left stance anterior parameter. This shows that gender does not have a significant effect on balance in CrossFit athletes. When the agility of the athletes participating in the study was examined by gender, it was observed that mean t-test scores for women were classified as poor, and mean t-test scores of men were classified as average agility levels. This shows that gender influences agility in CrossFit athletes. According to gender, it was observed that the side bridge core endurance scores of female athletes were lower than male athletes. However, this does not apply to extensor and flexor core muscle endurance. Therefore, the effect of gender on core endurance cannot be directly explained.

The limitations of our study;

-The athlete’s training variation is one of the limitations of our study. Because of the nature of CrossFit, the training changes day by day. All athletes are from the same CrossFit Box. However, their training days of them have differences.

-Our study gives baseline information about CrossFit athletes and their physical abilities. However, there is more physical ability to need research such as flexibility.

-Some of the CrossFit athletes train more than WOD program, they might be focused on weightlifting, callisthenics, or powerlifting. Therefore, our findings might be affected by this additional training.

Because of the pandemic, our study gives information about athletes from one CrossFit box. To reach more general information future studies might examine different institutes. Although our sample size has a power of 95%, it could have been higher.

6. CONCLUSION

As a result, the study found a relationship between the side core endurance and agility levels of CrossFit athletes. The agility levels of CrossFit athletes were observed as average and poor in the t agility test. It was observed that the agility levels of male CrossFit athletes were better than female CrossFit athletes Gender has been found to influence agility in CrossFit athletes, but its effect on core stabilization cannot be directly explained.

There was no relationship between balance and agility levels in CrossFit athletes. Additionally, there is no impact of gender on balance parameters in CrossFit athletes.

There is a significant relationship between core endurance and agility in CrossFit athletes. These two parameters affect by backward to each other. Accordingly, it means that athletes with better side core endurance finish the t-test faster and has better agility. On the other hand, there was no significant relationship between flexor-extensor endurance parameters and agility.

It was observed that female Crossfit athletes had low side core endurance levels than male CrossFit athletes. However, this does not apply to extensor and flexor core muscle endurance. Therefore, the effect of gender on core endurance cannot be directly explained.

Body fat percentage was found lower in female CrossFit athletes than in male CrossFit athletes. As a result of it, Gender has an effect on body fat percentage in Crossfit athletes. In addition, the study shows that there is no relationship between BFR and balance, core endurance, and agility.

7. REFERENCES

1. Bergmark, A. (1989). Stability Of The Lumbar Spine. Acta Orthopaedica Scandinavica, 60(Sup230), 1-54.

2. Bashir, S., Nuhmani, S., Dhall, R., & Muaidi, Q. (2019). Effect Of Core Training On Dynamic Balance And Agility Among Indian Junior Tennis Players. Journal Of Back And Musculoskeletal Rehabilitation, 32(2), 245-252.

3. Karpiński, J., Rejdych, W., Brzozowska, D., Gołaś, A., Sadowski, W., & Swinarew, A. Et Al. (2020). The Effects Of A 6-Week Core Exercises On Swimming Performance Of National Level Swimmers. Plos One, 15(8), E0227394.

4. The Crossfit Training Guide. Crossfit.Com. Retrieved 6 June 2022, From Https://Www.Crossfit.Com/Cf-Seminars/Certrefs/Cf_Manual_V4.Pdf.

5. Summitt, R., Cotton, R., Kays, A., & Slaven, E. (2016). Shoulder Injuries İn Individuals Who Participate İn Crossfit Training. Sports Health: A Multidisciplinary Approach, 8(6), 541-546.

6. Meyer, J., Morrison, J., & Zuniga, J. (2017). The Benefits And Risks Of Crossfit: A Systematic Review. Workplace Health &Amp; Safety, 65(12), 612-618.

7. Glassman, G. (2007). Level 1 Training Guide. Crossfit Journal, 1-255.

8. Silva-Grigoletto, M., Heredia-Elvar, J., & Oliveira, L. (2020). “Cross” Modalities: Are The Amrap, Rft And Emom Models Applicable To Health? Revista Brasileira De Cineantropometria &Amp; Desempenho Humano, 22.

9. Tabata, I., Nıshımura, K., Kouzakı, M., Hıraı, Y., Ogıta, F., Mıyachı, M., & Yamamoto, K. (1996). Effects Of Moderate-İntensity Endurance And High-İntensity İntermittent Training On Anaerobic Capacity And Vo2max. Medicine &Amp; Amp Science In Sports &Amp; Amp Exercise, 28(10), 1327-1330.

10. Morrone, B., & Spaccarotella, K. (2018). Comparıson Of Balance Between Genders Of Crossfıt Athletes. Graduate Journal Of Sport, Exercise & Physical Education Research, 10, 1-11.

11. Hrysomallis, C. (2011). Balance Ability And Athletic Performance. Sports Medicine, 41(3), 221-232.

12. Wıllardson, J. (2007). Core Stabılıty Traınıng. Journal Of Strength And Conditioning Research, 21(3), 979-985.

13. Wıllardson, J. (2007). Core Stabılıty Traınıng. Journal Of Strength And Conditioning Research, 21(3), 979-985.

14. Glassman, G. (2021). Competition Rule Book (pp. 1-34).

15. Weisenthal, B., Beck, C., Maloney, M., Dehaven, K., & Giordano, B. (2014). Injury Rate And Patterns Among Crossfit Athletes. Orthopaedic Journal Of Sports Medicine, 2(4), 232596711453117.

16. Klimek, C., Ashbeck, C., Brook, A., & Durall, C. (2018). Are Injuries More Common With Crossfit Training Than Other Forms Of Exercise? Journal Of Sport Rehabilitation, 27(3), 295-299.

17. Hülsmann, M., Reinecke, K., Barthel, T., & Reinsberger, C. (2021). Musculoskeletal Injuries In Crossfit®: A Systematic Review And Meta-Analysis Of Injury Rates And Locations. German Journal Of Sports Medıcıne, 72(7), 351-35

18. Jusdado-García, M., & Cuesta-Barriuso, R. (2021). Soft Tissue Mobilization and Stretching For Shoulder İn Crossfitters: A Randomized Pilot Study.

19. Silfies, S., Ebaugh, D., Pontillo, M., & Butowicz, C. (2015). Critical Review Of The İmpact Of Core Stability On Upper Extremity Athletic İnjury And Performance. Brazilian Journal of Physical Therapy, 19(5), 360-368.

20. Zemková, E., & Hamar, D. (2014). Agility Performance İn Athletes Of Different Sport Specializations. Acta Gymnica, 44(3), 133-140.

21. Barfield, J., & Anderson, A. (2014). Effect Of Crossfıt™ On HealthRelated Physıcal Fıtness: A Pılot Study. Journal Of Sport and Human Performance, 2(1), 23-28.

22. Laursen, P., & Jenkins, D. (2002). The Scientific Basis for HighIntensity Interval Training. Sports Medicine, 32(1), 53-73. Https://Doi.Org/10.2165/00007256-200232010-0000

23. Haddadi Esfahani, N., Dommerholt, J., & Sadat Rezaeian, Z. (2021). Core Muscles Endurance İn Sedentary Individuals with And Without Nonspecific Chronic Low Back: A Cross-Sectional Study. Muscle Ligaments and Tendons Journal, 11(01), 136. Https://Doi.Org/10.32098/Mltj.01.2021.15

24. Claudino, J., Gabbett, T., Bourgeois, F., Souza, H., Miranda, R., & Mezêncio, B. Et Al. (2018). Crossfit Overview: Systematic Review and Meta-Analysis. Sports Medicine - Open, 4(1). Https://Doi.Org/10.1186/S40798-018-0124-5

25. Hak, P., Hodzovic, E., & Hickey, B. (2013). The Nature and Prevalence Of İnjury During Crossfit Training. Journal Of Strength and Conditioning Research, Publish Ahead Of Print.

26. Paine, J., Uptgraft, J., & Wylie, R. (2010). Command And General Staff College Crossfit Study, 1-69.

27. Schlegel, P. (2020). CrossFit® Training Strategies from The Perspective Of Concurrent Training: A Systematic Review. Journal Of Sports Science and Medicine, 19, 670-680.

28. Butcher, S., Neyedly, T., Horvey, K., & Benko, C. (2015). Do Physiological Measures Predict Selected Crossfit&Amp; Reg; Benchmark Performance? Open Access Journal Of Sports Medicine, 241. Https://Doi.Org/10.2147/Oajsm.S88265

29. Sibley, B., & Bergman, S. (2017). What Keeps Athletes İn The Gym? Goals, Psychological Needs, And Motivation Of Crossfit™ Participants. International Journal Of Sport And Exercise Psychology, 16(5), 555-574.

30. Lavallee, M., & Mansfield, L. (2013). Weightlifting Training Gives Lifelong Benefits. Acsm's Health &Amp; Fitness Journal, 17(2), 34-36.

31. Gymnastıcs Traınıng Guıde. Assets.Crossfit.Com. Retrieved 6 June 2022, From Https://Assets.Crossfit.Com/Pdfs/Seminars/Smerefs/Gymnastics/Gymnasticscourse_Seminarguide.Pdf.

32. Schultz, J., Parker, A., Curtis, D., Daniel, J., & Huang, H. (2022). The Physiological and Psychological Benefits Of Crossfit Training – A Pilot Study. International Journal Of Exercise Science.

33. Smith, M., Sommer, A., Starkoff, B., & Devor, S. (2013). Crossfit-Based High-Intensity Power Training Improves Maximal Aerobic Fitness and Body Composition [Retracted]. Journal Of Strength and Conditioning Research, 27(11), 3159-3172.

34. Laursen, P. (2010). Training For İntense Exercise Performance: Highİntensity Or High-Volume Training? Scandinavian Journal Of Medicine &Amp; Science In Sports, 20, 1-10.

35. Mangine, G., Stratton, M., Almeda, C., Roberts, M., Esmat, T., Vandusseldorp, T., & Feito, Y. (2020). Physiological Differences Between Advanced Crossfit Athletes, Recreational Crossfit Participants, And Physically Active Adults. Plos One, 15(4), E0223548.

36. Mcweeny, D. (2019). The Effect Crossfit Vs. Resistance Training on Aerobic, Anaerobic And Musculoskeletal Fitness. University Of Alberta.

37. Meyer, J., Morrison, J., & Zuniga, J. (2017). The Benefits and Risks of Crossfit: A Systematic Review. Workplace Health &Amp; Safety, 65(12), 619-619.

38. Toledo, R., Dias, M., Toledo, R., Erotides, R., Pinto, D., & Reis, V. Et Al. (2021). Comparison Of Physiological Responses And Training Load Between Different CrossFit® Workouts With Equalized Volume İn Men And Women. Life, 11(6), 586.

39. Cadegiani, F., Kater, C., & Gazola, M. (2019). Clinical And Biochemical Characteristics of High-İntensity Functional Training (HIFT) And Overtraining Syndrome: Findings from The Eros Study (The Eros-Hıft). Journal Of Sports Sciences, 37(11), 1296-1307.

40. Üner, İ. (2022). Evaluation Of Static and Dynamic Balance Among Subjects Having CrossFit Training Regularly. T.C. Yeditepe Üniversitesi.

41. Chander, H., Macdonald, C., Dabbs, N., Allen, C., Lamont, H., & Garner, J. (2014). Balance Performance İn Female Collegiate Athletes. Journal Of Sports Science, 2, 13-20.

42. Cheng, J., Chiu, C., & Su, T. (2019). Training and Evaluation of Human Cardiorespiratory Endurance Based on a Fuzzy Algorithm. International Journal of Environmental Research and Public Health, 16(13), 2390.

43. Clark, D., Lambert, M., & Hunter, A. (2018). Contemporary Perspectives Of Core Stability Training For Dynamic Athletic Performance: A Survey Of Athletes, Coaches, Sports Science And Sports Medicine Practitioners. Sports Medicine - Open, 4(1).

44. Huxel Bliven, K., & Anderson, B. (2013). Core Stability Training For Injury Prevention. Sports Health: A Multidisciplinary Approach, 5(6), 514-522.

45. Brumitt, J., Matheson, J., & Meira, E. (2013). Core Stabilization Exercise Prescription, Part I. Sports Health: A Multidisciplinary Approach, 5(6), 504- 509.

46. Gibbons, S., & Comerford, M. (2001). Strength Versus Stability Part I; Concept and Terms. Orthopaedic Division Review, 21-27.

47. Gamble, P. (2007). An Integrated Approach to Training Core Stability. Strength And Conditioning Journal, 29(1), 38-39.

48. Drake, R., Vogl, W., Mitchell, A., & Drake, R. Gray's atlas of anatomy.

49. Sobotta, Putz, R., Pabst, R., Putz, R., & Bedoui, S. (2006). Sobotta. Elsevier, Urban & Fischer.

50. Hodges, P., & Richardson, C. (1998). Delayed Postural Contraction Of Transversus Abdominis İn Low Back Pain Associated With Movement Of The Lower Limb. Journal Of Spinal Disorders, 11(1), 46-56.

51. Hodges, P., & Richardson, C. (1998). Delayed Postural Contraction Of Transversus Abdominis İn Low Back Pain Associated With Movement Of The Lower Limb. Journal Of Spinal Disorders, 11(1), 46-56.

52. Sapsford, R., Hodges, P., Richardson, C., Cooper, D., Markwell, S., & Jull, G. (2000). Co-Activation Of The Abdominal And Pelvic Floor Muscles During Voluntary Exercises. Neurourology And Urodynamics, 20(1), 31-42.

53. Akuthota, V., Ferreiro, A., Moore, T., & Fredericson, M. (2008). Core Stability Exercise Principles. Current Sports Medicine Reports, 7(1), 39-44.

54. Nelson, N. (2012). Diaphragmatic Breathing The Foundation Of Core Stability. Strength &Amp; Conditioning Journal, 34(5), 34-40.

55. Sapsford, R. (2004). Rehabilitation Of Pelvic Floor Muscles Utilizing Trunk Stabilization. Manual Therapy, 9(1), 3-12.

56. Özengin, N., Yıldırım, N., & Duran, B. (2015). A Comparison Between Stabilization Exercises and Pelvic Floor Muscle Training İn Women With Pelvic Organ 69 Prolapse. Journal Of Turkish Society Of Obstetrics And Gynecology, 12(1), 11-17.

57. Kibler, W., Press, J., & Sciascia, A. (2006). The Role Of Core Stability İn Athletic Function. Sports Medicine, 36(3), 189-198.

58. Dello Iacono, A., Padulo, J., & Ayalon, M. (2015). Core Stability Training On Lower Limb Balance Strength. Journal Of Sports Sciences, 34(7), 671-678.

59. Ozmen, T., & Aydogmus, M. (2016). Effect Of Core Strength Training On Dynamic Balance And Agility İn Adolescent Badminton Players. Journal Of Bodywork And Movement Therapies, 20(3), 565-570.

60. Martins, H., Lüdtke, D., César De Oliveira Araújo, J., Cidral-Filho, F., Inoue Salgado, A., Viseux, F., & Martins, D. (2019). Effects Of Core Strengthening On Balance İn University Judo Athletes. Journal Of Bodywork And Movement Therapies, 23(4), 758-765.

61. Reed, C., Ford, K., Myer, G., & Hewett, T. (2012). The Effects Of Isolated And Integrated ‘Core Stability’ Training On Athletic Performance Measures. Sports Medicine, 42(8), 697-706.

62. Szafraniec, R., Baranska, J., & Kuczynskı, M. (2018). Acute Effects of Core Stability Exercises On Balance Control. Acta Of Bioengineering and Biomechanics, 20(3)

63. Raıola, G., Domenico, F., D'ısanto, T., Altavılla, G., & D'elia, F. (2020). Bıomechanıcs Core. Acta Medica Mediterranea, 36, 3079-3083.

64. Panjabi, M. (1992). The Stabilizing System of The Spine. Part I. Function, Dysfunction, Adaptation, And Enhancement. Journal Of Spinal Disorders, 5(4), 383-389.

65. Pollock, A., Durward, B., & Rowe, P. (2000). What İs Balance? Clinical Rehabilitation, 14, 402-406.

66. Watson, M., Black, F., & Crowson, M. (2020). The Human Balance System: A Complex Coordination Of Central And Peripheral Systems. Vestibular Disorders Association.

67. Bressel, E., Yonker, J., Kras, J., & Heath, E. (2007). Comparison Of Static And Dynamic Balance İn Female Collegiate Soccer, Basketball, And Gymnastics Athletes. Journal Of Athletic Training, 42(1), 42-46.

68. Johnston, W., Duignan, C., Coughlan, G., & Caulfield, B. (2018). Dynamic Balance Performance Varies By Position But Not By Age Group İn Elite Rugby Union Players – A Normative Study. Journal Of Sports Sciences, 37(11), 1308- 1313.

69. Davlın, C. (2004). Dynamıc Balance In Hıgh Level Athletes. Perceptual And Motor Skills, 98(3), 1171.

70. Yaggie, J., & Campbell, B. (2006). Effects Of Balance Training On Selected Skills. The Journal Of Strength And Conditioning Research, 20(2), 422.

71. Zemková, E. (2013). Sport-Specific Balance. Sports Medicine, 44(5), 579-590. Https://Doi.Org/10.1007/S40279-013-0130-1

72. Level 2 Traınıng Guıde And Workbook Course Overvıew, 1-80.

73. Paul, D., Gabbett, T., & Nassis, G. (2015). Agility İn Team Sports: Testing, Training And Factors Affecting Performance. Sports Medicine, 46(3), 421-442.

74. Sheppard, J., & Young, W. (2006). Agility Literature Review: Classifications, Training And Testing. Journal Of Sports Sciences, 24(9), 919-932. Https://Doi.Org/10.1080/02640410500457109

75. Horička, P. (2021). The Influence Of Age Factor And Sports Specialization On The Level Of Agility İn Sports Games. Studia Universitatis Babeş- 71 Bolyai Educatio Artis Gymnasticae, 66(4), 5-15.

76. Horička, P., Hianik, J., & Šimonek, J. (2014). The Relationship Between Speed Factors And Agility İn Sport Games. Journal Of Human Sport And Exercise, 9(1), 49-58.

77. Hojka, V., Stastny, P., Rehak, T., Gołas, A., Mostowik, A., Zawart, M., & Musálek, M. (2016). A Systematic Review Of The Main Factors That Determine Agility İn Sport Using Structural Equation Modeling. Journal Of Human Kinetics, 52(1), 115-123.

78. Young, W., & Farrow, D. (2006). A Review of Agility: Pratical Applications For Strength And Conditioning. Strength And Conditioning Journal, 28(5), 24-29.

79. Benis, R., Bonato, M., & Torre, A. (2016). Elite Female Basketball Players' Body-Weight Neuromuscular Training and Performance on the Y-Balance Test. Journal Of Athletic Training, 51(9), 688-695.

80. Vogler, J., Csiernik, A., Yorgey, M., Harrison, J., & Games, K. (2017). Clinician-Friendly Physical Performance Tests for The Hip, Ankle, And Foot. Journal Of Athletic Training, 52(9), 861-862.

81. Shaffer, S., Teyhen, D., Lorenson, C., Warren, R., Koreerat, C., Straseske, C., & Childs, J. (2013). Y-Balance Test: A Reliability Study Involving Multiple Raters. Military Medicine, 178(11), 1264-1270.

82. Alshehre, Y., Alkhathami, K., Brizzolara, K., Weber, M., & Wang-Price, S. (2021). Reliability And Validity of the Y-Balance Test İn Young Adults with Chronic Low Back Pain. International Journal of Sports Physical Therapy, 16(3).

83. Bittencourt, N., Leite, M., Garcia, L., Mendonça, L., Bithencourt, A., & Gonçalves, G. (2017). Y- Balance Test Score Comparison Between Pre-Season and In-Season In Youth Athletes. British Journal of Sports Medicine, 51(4), 298.1-298.

84. Wen, N., Dalbo, V., Burgos, B., Pyne, D., & Scanlan, A. (2018). Power Testing İn Basketball: Current Practice and Future Recommendations. Journal Of Strength and Conditioning Research, 32(9), 2677-2691.

85. Pauole, K., Madole, K., Garhammer, J., Lacourse, M., & Rozenek, R. (2000). Reliability And Validity of The T-Test As A Measure Of Agility, Leg Power, And Leg Speed İn College-Aged Men And Women. Journal Of Strength and Conditioning Research, 14(4), 443-450.

86. Plisky, P., Gorman, P., Butker, R., Kiesel, K., Underwood, F., & Elkins, B. (2009). The Reliability Of An İnstrumented Device For Measuring Components Of The Star Excursion Balance Test. North American Journal Of Sports Physical Therapy, 4(2), 92-99.

87. Pauole, K., Madole, K., Garhammer, J., Lacourse, M., & Rozenek, R. (2000). Reliability And Validity of The T-Test As A Measure Of Agility, Leg Power, 67 And Leg Speed İn College-Aged Men And Women. Journal Of Strength And Conditioning Research, 14(4), 443-450.

88. Mcgill, S. (2015). Mcgill's Torsomuscular Endurance Test Battery. American Council of Exercise. Url: Https://Www. Acefitness. Org/Cmes-Resources/Pdfs/02-10-Cmes-Mcgillstorsoenduracnetest. Pdf

89. Mcıntosh, G., Affleck, M., & Hall, H. (1998). Trunk And Lower Extremity Muscle Endurance: Normative Data for Adults. Journal Of Rehabilitation Outcomes Measurement, 2(4), 20-39

90. Martínez-Romero, M., Ayala, F., De Ste Croix, M., Vera-Garcia, F., Sainz De Baranda, P., Santonja-Medina, F., & Sánchez-Meca, J. (2020). A MetaAnalysis of The Reliability Of Four Field-Based Trunk Extension Endurance Tests. International Journal of Environmental Research and Public Health, 17(9), 3088.

91. Nesser, T., Huxel, K., Tincher, J., & Okada, T. (2008). The Relationship Between Core Stability and Performance İn Division I Football Players. Journal Of Strength and Conditioning Research, 22(6), 1750-1754.

92. Reiman, M., Krier, A., Nelson, J., Rogers, M., Stuke, Z., & Smith, B. (2022). Comparison Of Different Trunk Endurance Testing Methods in College-Aged Individuals. Pubmed Central (Pmc).

93. Claxton, M., & Mcıntosh, G. (2009). Sidebridge Muscle Endurance Testing: Normative Data for Adults. Orthopaedic Division Review, 35-39

94. Ng, B., Hinton, B., Fan, B., Kanaya, A., & Shepherd, J. (2016). Clinical Anthropometrics and Body Composition From 3d Whole-Body Surface Scans. European Journal of Clinical Nutrition, 70(11), 1265-1270.

95. Wagner, D., Castaneda, F., Bohman, B., & Sterr, W. (2019). Comparison Of A 2d İpad Application And 3d Body Scanner to Air Displacement Plethysmography for Measurement Of Body Fat Percentage. Journal Of Human Nutrition and Dietetics, 1-8.

96. Cabre, H., Blue, M., Hirsch, K., Brewer, G., Gould, L., Nelson, A., & Smith-Ryan, A. (2021). Validity Of A 3-Dimensional Body Scanner: Comparison Against A 4-Compartment Model and Dual Energy X-Ray Absorptiometry. Applied Physiology, Nutrition, And Metabolism, 46(6), 644-650.

97. Oliver, J., Lambert, B., Martin, S., Tanguay, J., Bragg, A., Green, J., & Crouse, S. (2011). Predicting Body Fat to The Accuracy of Dexa Using Standard Anthropometric Measures. Journal Of Strength and Conditioning Research, 25, S38-S39.

98. Santos, M., Behm, D., Barbado, D., DeSantana, J., & Da Silva-Grigoletto, M. (2019). Core Endurance Relationships with Athletic and Functional Performance in Inactive People. Frontiers In Physiology, 10.

99. Morrone, B. (2018). Comparison of Balance Between Genders of CrossFit Athletes. Kean University

100. Ozmen, T. (2016). Relationship between core stability, dynamic balance and jumping performance in soccer players. Turkish Journal Of Sport And Exercise, 18(1), 110.

101. Nourizadeh, S., Mirjani, M., & Naserpour, H. (2019). The Relationship Between Core Stability, Muscular Endurance, and Static Balance, and Shooting Function in Military Soldiers. Journal of Sport Biomechanics, 62-71.

102. Çelik, N., Kılıç, M., & Taşkın, H. (2017). The Effect Of Balance On Agılıty In Soccer Players. Ovidius University Annals, Series Physical Education And Sport / Scıence, Movement And Health, 17(2), 233-237.

103. Rokaya, A., Roshan, P., Shetty, S., & Joseph D'souza, C. (2021). Relationship between Dynamic Balance and Agility in Trained Soccer Players – A Correlational Study. International Journal Of Scientific And Research Publications (IJSRP), 11(7), 127-132.

104. Mohammad, A., & Tareq, A. (2022). The Relationship between Body Fat Percentage with Speed, Agility and Reaction Time of Male Football Players of Bangladesh. International Journal of Science Culture and Sport, 4(4), 453-460

7.APPENDIXES

7.1. Appendix 1 Ethic Committe Approval

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

Versiyon No
1.0
Sayfa 2 / 2

BAŞVURU NUMARASI: 202112124

KARAR 27.01.2022

☒ **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				**Doç. Dr. Mehmet Engin CELEP Üye**				**Dr. Öğr. Üyesi E. Çiğdem KELEŞ Üye**			
Katılım		İlişki		Katılım		İlişki		Katılım		İlişki	
☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok
Dr. Öğr. Üyesi Binnur OKAN BAKIR Üye				**Dr. Öğr. Üyesi E. Nur ÖZDAMAR Üye**				**Dr. Öğr. Üyesi SEVİM ŞEN Üye**			
Katılım		İlişki		Katılım		İlişki		Katılım		İlişki	
☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok	☐Var	☐Yok

Araştırmanın Başlığı	Crossfit Sporcularında Kor Stabilizasyon Denge ve Çeviklik Parametreleri Arasındaki İlişkinin Araştırılması
Araştırmacılar	Fzt. Başak Biçer, Prof. Dr. Feryal Subaşı

7.2 Appendix 2 Informed Written Consent

BİLGİLENDİRİLMİŞ SPORCU OLUR FORMU

Yeditepe Üniversitesi, Sağlık Bilimleri Fakültesi, Fizyoterapi ve Rehabilitasyon Bölümü Spor **Fizyoterapisi Anabilim Dalı**, Yüksek Lisans Tezi için hazırlanan "Crossfit sporcularında kor stabilizasyon denge ve çeviklik parametreleri arasındaki ilişkisinin araştırılması" adlı araştırma kapsamında Crossfit sporcularında kor stabilizasyonu, denge ve çeviklik arasındaki ilişkiyi incelemeyi planlamaktayız.

Çalışmaya katılım gönüllülük esasına dayalıdır. Çalışmaya katılmadan önce araştırmanın neden ve nasıl yapılacağı, bilgilerinin nasıl kullanacağını ve çalışmanın neleri içerdiğini anlamanız önemlidir. Lütfen aşağıdaki bilgileri dikkatlice okumak için zaman ayırınız. Eğer sizin için açık olmayan şeyler varsa ya da daha fazla bilgi almak isterseniz lütfen bize sorunuz. Bu bilgileri okuyup anladıktan sonra araştırmaya katılmak isterseniz formu imzalayınız.

Araştırmaya davet edilmenizin nedeni: Günümüzde Crossfit, daha ünlü ve favori seçenek haline gelmektedir ancak, literatür çalışmaları hala crossfit için yeterli açıklama sağlayamamaktadır. Bu çalışma sonucunda crossfit ile ilgilenen sporcuların çeviklik, denge ve kor stabilizasyon düzeyleri hakkında bilgi edinilmesi amaçlanmıştır.

Araştırma kapsamında çalışmaya katılmayı kabul eden gönüllü bireylere çevikliği ölçmek amacıyla T çeviklik testi, Kor stabilizasyonu değerlendirmek için McGill kor endurans testi, dengeyi değerlendirmek için Y denge testi ve vücut yağ oranını değerlendirmek için vücut kompozisyon analizi uygulanacaktır. Çalışmamızda olgular kesitsel olarak değerlendirilecek, etken ve sonuç aynı anda gözlemlenecektir. Araştırmada yapılan değerlendirmelerin sonuçları yalnızca araştırma kapsamındaki çalışmalarda kullanılacaktır. Kişisel bilgiler herhangi bir amaçla, kurum yöneticileri veya üçüncü kişilerle paylaşılmayacaktır.

Araştırmaya katılmayı kabul ederseniz, değerlendirmeleriniz Fzt. Başak BİÇER tarafından yapılacak ve bulgular kaydedilecektir. Araştırma kapsamında, girişimsel olmayan fiziksel değerlendirmeler ve performans testleri uygulanacaktır. Çalışmaya katılmakla herhangi bir parasal yük altına girmeyeceksiniz ve aynı şekilde bir ödeme yapılmayacaktır. Araştırma bir kongrede ya da dergide yayın olarak kabul edilse bile kimliğinizi ortaya çıkarabilecek kayıtlar gizli tutulacaktır. Araştırmaya katılım tamamen isteğe bağlıdır. İstediğiniz zaman herhangi bir ceza veya yaptırıma maruz kalmaksızın araştırmadan çekilebilirsiniz.

Değerlendirme Yöntemleri

- **Y Denge Testi:** Katılımcıların dinamik dengesi Y şeklindeki bir platformda değerlendirilecektir.
- **McGill Kor Test:** Kor bölgesinin dayanıklılık testi, derin çekirdek kaslarının kas dayanıklılığını değerlendiren üç testin oluşur. Ön, yan ve arka kasların statik, izometrik bir şekilde kasılmasını içeren, kişi yorgunluk sergileyene kadar omurgayı stabilize eden, zamanlı bir testtir.
- **T Çeviklik Testi:** Birleşik becerileri ölçmekte ve mümkün olan en hızlı zamanda önceden planlanmış bir hareket dizisini tamamlamayı içermektedir.
- **Vücut Kompozisyon Analizi:** Vücut kompozisyon değerlendirmeleri için 3 boyutlu vücut kompozisyon analizi cihazı kullanılacaktır. Sabit şekilde 40 saniye durduğunuz pozisyonda cihaz kızılötesi ışınlar ile vücut taramanızı gerçekleştirecek ve analizinizi raporlayacaktır.
- Çalışma ile Crossfit sporcularında kor stabilizasyonu, denge ve atletik performans arasındaki ilişki araştırılacaktır.

SORUMLU ARAŞTIRMACILAR:

Prof. Dr. Feryal SUBAŞI – Fzt. Başak BİÇER

İLETİŞİM: Fzt. Başak Biçer

+90 0531 522 60 02

"CROSSFİT **SPORCULARINDA KOR STABİLİZASYON DENGE VE ÇEVİKLİK PARAMETRELERİ ARASINDAKİ İLİŞKİNİN ARAŞTIRILMASI"** adlı bu çalışmaya hiçbir baskı ve zorlama olmaksızın kendi rızamla katılmayı kabul ediyorum.

Gönüllü;	**Açıklamaları Yapan Kişi;**	**Tanık;**
Adı, Soyadı:	**Adı, Soyadı:**	**Adı, Soyadı:**
Telefon:	**Adres:**	**Telefon:**
İmza:	**İmza:**	**İmza:**
Tarih:	**Tarih:**	**Tarih:**

7.2. APPENDIX 3 Structured Questionnaire for Demographic Characteristics

Katılımcı Değerlendirme Formu Tarih…/…. /……

1)Ad Soyad: **Telefonu:**

2)Cinsiyet: □ Kadın □Erkek

3)Yaş:

4)Boy / kilo:

5)BMI

6)Vücut yağ oranı:

7)Dominant taraf;

El : Sağ □ Sol □

Ayak: Sağ □ Sol □

8)Medeni durumu:

□ Bekar □Evli □ Boşanmış □ Ayrı yaşıyor □ Eşi ölmüş

9)Eğitim durumu:

□ Okur yazar değil □İlköğretim □Lise □Üniversite

□ Yüksek Lisans/Doktora

10)Çalışıyor musunuz?

□Evet □Hayır

11)Mesleğiniz:

12)Maddi durumunuz: □1000TL'den az □ 1000-2000TL □2000-3000TL □3000TL ve üzeri

13)Sosyal Güvenceniz: □ Var □Yok

14)Çocuğunuz: □ Var □Yok Varsa kaç çocuğunuz var?.......

15)Şu an yaşadığı yer: □ Ev □Yurt □ Diğer Belirtiniz……

16)Sigara içiyor musunuz? İçiyorsanız ne sıklıkta?

İçmiyorum □ İçtim ama bıraktım □ içiyorum □

17)İçiyorsanız ne sıklıkta?

Günde 1-2 adet □ Günde 3-5 adet □ Günde 6-10 adet □

Günde 10-20 adet □ Günde 1 paket □ Günde 1 paketten fazla □

18)Alkol Kullanıyor musunuz?

□ Hiç kullanmadım

□ Az miktarda /kısa süreli(nadir)

□ Orta düzeyde/10 yıldan az

□ Fazla miktarda /uzun süredir

19) Doktor tarafından teşhisi konmuş herhangi bir hastalığınız var mı?

□Evet □Hayır

20)Cevabınız evet ise teşhis edilen hastalığınız aşağıdakilerden hangisi/hangileridir? (Birden fazla şıkkı işaretleyebilirsiniz)

□ Kalp damar hastalıkları □Kanser □Şeker Hastalığı

□ Romatizma

□ Ortopedik Hastalık

□ Nörolojik Problemler

□ Travma

□ Sindirim sistemi hastalıkları (karaciğer, mide vb.)

□Yüksek tansiyon □Solunum sistemi hastalıkları (akciğer vb.)

□ Ruhsal sorunlar (depresyon, aşırıyeme, kusma, gece yeme vb.)

□ Kas-iskelet sistemi problemleri

□ Endokrin (hormonal) hastalıklar

□Vitamin ve mineral yetersizlikleri (Demir, B12 vitamini yetersizliği vb.)

□ Diğer (Belirtiniz)………………

21) Düzenli kullanılan ilaç var mı?

Evet □ Hayır □ İlaç ismi:

22)Daha önce medikal operasyon geçirildi mi?

Evet □ Hayır □ Bölge ve işlem:

23) Hiç kaza geçirdiniz mi?

Evet □ Hayır □

24) Kaza geçirdiyseniz ne zaman geçirdiniz?

1 yıl içinde □ 1 yıldan önce □

25)Kas iskelet sistemine bağlı herhangi bir ağrı şikayetiniz var mı? Varsa hangi bölgede?

Ağrım yok □

Bel □ Kalça □ Diz □ Ayak □

26)Spor yapıyor musunuz? Yapıyorsanız ne sıklıkta?

Yapmıyorum □

Ayda bir kez den az □ Ayda 2 kez ve fazla □ Haftada 1 kez □

Haftada 2-3kez □ Haftada 4-5 kez □ Her gün □

27)Spor yapıyorsanız ne kadar zamandır?

3aydan az □ 3-6ay □ 6ay-1yıl □ 1-3yıl □ 3yıldan fazla □

28)Spor yapıyorsanız yaptığınız spor her seferinde kaç dakika sürüyor?

20 dk az □ 20-30 dk □ 30–60 dk □ 60 dk. dan fazla □

29)Herhangi bir spor dalıyla ilgilendiniz mi?

□ Hayır □Evet

30) Cevabınız evet ise hangisi?

□ Futbol

□ Basketbol

□ Voleybol

□ Hentbol

□ Atletizm

□ Tenis

□ Su topu

□Yüzme

□Crossfit

□ Diğer……………………

25)Kas iskelet sistemine bağlı herhangi bir sakatlanma geçirdiniz mi?

Evet □ Hayır □

Evet ise.

- **Ne zaman?**
- **Hangi bölge/ler?**

Boyun □ Sırt □ Bel □ Kalça □ Diz □ Ayak □

- **Tedavi şekliniz?**

- **Varsa devam eden şikayetleriniz?**

7.3. APPENDIX 4 Y Balance Score Sheet

Score Sheet for Y Balance Test™ & Limb Length

Athlete Name: ______________________________ Date: ____________________

RIGHT Limb Length: __________________

	Left	Right	Difference
Anterior			
Posteromedial			
Posterolateral			

*** Difference should be less than 4 cm. for return to sport and preparticipation screening ***

$$\text{Composite Score} = \frac{(\text{Anterior} + \text{Posteriomedial} + \text{Posterolateral})}{(3 \times \text{Limb Length})} \times 100$$

Composite	
Right	
Left	

7.4. APPENDIX 5 McGill Core Test Score Sheet

Trunk flexor endurance test
Time to completion: ____________

Trunk lateral endurance test
Right side time to completion: __________ Left side time to completion: __________

Trunk extensor endurance test
Time to completion: ____________

Ratio of Comparison	Criteria for Good Relationship Between Muscles
Flexion:extension	Ratio less than 1.0
Right-side bridge:left-side bridge	Scores should be no greater than 0.05 from a balanced score of 1.0
Side bridge (each side):extension	Ratio less than 0.75

Flexion:extension ratio: ____________ Rating: ❑ Good ❑ Poor

Right-side bridge:left-side bridge ratio: ________ Rating: ❑ Good ❑ Poor

Side-bridge (each side):extension ratio: ________ Rating: ❑ Good ❑ Poor

Figure 4
McGill's torso muscular endurance test battery—record sheet