T.C.

YEDITEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

MASTER’S PROGRAM IN SPORTS PHYSIOTHERAPY AND

REHABILITATION

EVALUATION OF STATIC AND DYNAMIC BALANCE AMONG SUBJECTS HAVING CROSSFIT TRAINING REGULARLY

MASTER THESIS

İrem ÜNER, PT

İSTANBUL-2022

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APPROVAL

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

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Director of Institute of Health Sciences

DECLARATION

I declare that this thesis is my own work, I do not have any unethical behavior at any stage from planning to writing, I get all the information in the thesis in academical and ethical rules, I give reference for all the information and comments that are not obtained by the thesis work, and I include these resources in the list of references, and, at the time of writing, I have not violated any patents and copyrights.

04.02.2022

İrem ÜNER

DEDICATION

I would like to dedicate my thesis to my beloved and lovely parents Aysun and Süreyya ÜNER and my brother Ahmet ÜNER.

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LIST OF SYMBOLS AND ABBREVIATIONS

A	Anterior
ACSM	American College Sports Medicine
AMRAP	As Many Reps As Possible
ASIS	Anterior Superior Iliac Spine
BESS	Balance Error Scoring System
BESST	Balance Error Scoring System Total
BMI	Body Mass Index
BoS	Base of Support
cm	centimeter
CTG	CrossFit Training Group
DLSHF	Double Leg Stance on Hard Floor
DLSSF	Double Leg Stance on Soft Floor
EMOM	Every Minute on the Minute
F	Female
FBT	Flamingo Balance Test
HIIT	High Intensity Interval Training
M	Male
MTC	Motor Control Test
n	number
PL	Posterolateral
PM	Posteromedial
rep	repetition
RFT	Round for Time

SEBT	Star Excursion Balance Test
SD	Standard Deviation
SG	Sedentary Group
SLSHF	Single Leg Stance on Hard Floor
SLSSF	Single Leg Stance on Soft Floor
SPSS	Statistical Package for Social Science
TLSHF	Tendem Leg Stance on Hard Floor
TLSSF	Tendem Leg Stance on Soft Floor
TSHF	Total Scor on Hard Floor
TSSF	Total Scor on Soft Floor
YBT	Y Balance Test
WOD	Work of Day
°	degree

ABSTRACT

Üner, İ. (2022). Evaluation Of Static and Dynamic Balance Among Subjects Having Crossfit Training Regularly. Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, Master Thesis. Istanbul.

The purpose of this study is to evaluate the effects of CrossFit training on the static and dynamic balance among subjects. The study included twenty volunteer amateur athletes (10M, 10K; 25-40 years old) who have been doing CrossFit training for at least 6 months and twenty volunteer sedentary individuals (10M, 10K; 25-40 years old) who did not do sports for at least 6 months. Both groups, static balance values of individuals were evaluated by Balance Error Scoring System (BESS), and dynamic balance were evaluated by Y Balance Test (YBT). The main results of our study comparing the two groups showed that the dynamic balance of the individuals who regularly performed CrossFit training was better than the sedentary individuals in all parameters of the YBT ($p < 0.05$). On the other hand, in some parameters of the BESS results, it was observed that the static balance of the individuals doing CrossFit training was better than the sedentary individuals. Consistent with the hypothesis, regular CrossFit training may be effective in positively improving static and dynamic balance in adults.

Key Words: CrossFit, static balance, dynamic balance, Y Balance Test, Balance Error scoring System, RFT, EMOM, AMRAP

ÖZET

Üner, İ. (2022). Düzenli Olarak Crossfit Antrenmanı Yapan Bireylerde Statik ve Dinamik Denge Değerlendirilmesi. Yeditepe Üniversitesi Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon ABD., Yüksek Lisans Tezi. İstanbul

Bu çalışmanın amacı; düzenli olarak yapılan CrossFit antrenmanlarının yetişkinlerin statik ve dinamik dengeleri üzerine olan etkilerini incelemektir. Çalışmaya amatör olarak en az 6 aydır Crossfit antrenmanı yapan 20 (10K, 10E ; 25-40 yaş) gönüllü sporcu ve en az 6 aydır her hangi bir spor dalı ile uğraşmamış 20 (10K, 10E ; 25-40 yaş) gönüllü sedanter birey dahil edildi. Her iki gruptaki bireylerin de statik denge değerleri Denge Hata Puanlama Sistemi (DHPS) ile , dinamik denge değerleri ise Y Denge Testi (YDT) ile değerlendirildi. İki grubu karşılaştıran çalışmamızın ana sonuçları, YDT'nin tüm parametrelerinde düzenli olarak crossfit antrenmanı yapan bireylerin dinamik dengelerinin sedanter bireylerden daha iyi olduğu gözlemlendi ($p<0.05$). DHPS sonuçlarının ise bazı parametrelerinde de CrossFit antrenmanı yapan bireylerin statik dengelerinin sedanter bireylere göre daha iyi olduğu gözlemlendi. Hipotezle uyumlu olarak, düzenli olarak CrossFit eğitimi almak yetişkinlerde statik ve dinamik dengeyi olumlu yönde geliştirmede etkili olabilir.

Anahtar Kelimeler: CrossFit, statik denge, dinamik denge, Y Denge Testi, Denge Hata Puanlama Sistemi, RFT, EMOM, AMRAP

1. INTRODUCTION AND PURPOSE

Greg Glassman created Crossfit in 1995 as a core strengthening and extreme conditioning program. Since the 2000s, this high-intensity interval training has become spreading and famous worldwide. CrossFit training is a sport that prepares the trainer for any physical contingency and improves general fitness(1). The definition of CrossFit refers to 'constantly varied, high intensity, functional movements'. Greg Glassman defines functional movements as patterns of motor movement performed in waves of contraction from the centre to the extremity over multiple joints. CrossFit training defined as the combination of Olympic weightlifting, powerlifting, sprints, plyometrics, callisthenics, gymnastics, and a few hard to categorize exercises like rope climbing (2,3,4).

The CrossFit program was produced primarily for military people, but it has become trendy in civil society. The exercise methods involve fast and repetitive movements with little or no rest. Crossfit workouts are short (usually 20 minutes or less), intense and functional movements and constantly changing exercises (3, 5, 6). In typical CrossFit exercises, athletes first perform warm-up training and then 'workout of day'(WOD). WODs vary from day to day. There are different training methods used in Crossfit training. These are Tabata Method(7), RFT or for time Method, AMRAP Method, EMOM Method and there are different programmes like Fran Program and Cindy Program. In our study, our participants use the RFT, EMOM, and AMRAP methods from these methods in their WODs. It was noted that the Crossfit Program improves many general physical abilities. He stated these physical characteristics as both aerobic and anaerobic endurance, strength, flexibility, power, speed, coordination, agility and balance (8). He also said that balance is a fundamental parameters for athletes participating in CrossFit. (9).

Balance is the ability to maintain a stable position even when the centre of gravity has shifted. It is maintained through the dynamic integration of internal and external forces and factors involving the environment. It is a fundamental skill required to complete activities of daily living that is reduced with age, subjecting a person to potential injury(10, 11). Static balance is defined as the ability to control the movement of the centre of gravity within the base of support under a given condition. It is the one achieved in a specific stop position. Dynamic balance is the ability to balance while in motion or switching between positions(12,13,14,15,16,17).

Due to the close relationship between balance and motor function capacity, balance plays an important role in maintaining balance and fulfilling given tasks in sports activities. Given that balance is a fundamental foundation for athletes participating in CrossFit, achieving and maintaining good balance is imperative. As far as we know, there is only one study in the literature on the evaluation of the balance effect of CrossFit on male and female CrossFit trainers (9). Crossfit competitions are organized in many countries, including our country. The number of participants is increasing every day. However, studies on CrossFit are limited. Therefore, this study aims to examine the effects of CrossFit training on adults' static and dynamic balance. The hypothesis of this study was following:

Hypothesis 0 (H0): Having CrossFit training regularly has no positive effectson static and dynamic balance in adults.

Hypothesis 1 (H1): Having CrossFit training regularly may have positive effects on static and dynamic balance in adults.

2.THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1. Crossfit

CrossFit was founded in 1995 by Greg Glassman, a physical fitness trainer and gymnast from Santa Cruz, CA. CrossFit is a constantly changing, high-intensity, functional movement training method. These functional movements include many joint movements. CrossFit training is a core strength and conditioning program. The aim of the CrossFit program is stated as improving general fitness and preparing trainees for any physical contingency. For this reason, Greg Glassman said that it is a system that focuses on producing programs to prepare athletes for any physical condition that is not only unknown but also unpredictable (1).

Crossfit examined all sports, physical exercise programs and training, and stated which physical characteristics are important in the performance of the athlete. It is not focused on specific features like other sports. In Crossfit training, many joints undertake many tasks in a short time, from carrying and throwing heavy loads to body weight and body movements. For this reason, it is a type of sport that is difficult to implement and needs attention (18,19,20).

There are CrossFit centers all over the world. Athletes attending these centers all follow a similar work of day (WOD). CrossFit is a set of exercises that include endurance, strength, power and metabolic conditioning (22). CrossFit was developed to improve some general physical skills. These physical skills are strength, cardiovascular/respiratory endurance, flexibility, stamina, speed, power, coordination, agility, accuracy and balanceThe CrossFit method is based on metabolic conditioning, diet, weightlifting, gymnastics, throwing and sports to achieve these goals (3). Metabolic conditioning combines both aerobic and anaerobic training styles with intervals to increase overall work CrossFit participants spend less time exercising per week. They were found to be able to sustain the fun while doing sports. Therefore, the majority of the participants continue the program (23).

2.1.1. Crossfit Training History in the World and Turkey

Crossfit is a high-intensity functional training model that has become very popular in recent years (4). This sport which was initially developed for military training was also adopted by civil society. In 1995, the first CrossFit hall was opened by

Greg Glassman. In 2000, it became a CrossFit company. In 2001, Greg Glassman launched a website describing the essential aspects of the Crossfit education system. On this page, he explained the system of CrossFit training, exercises, programs, and diet (1).

Since its establishment, Crossfit has become popular all over the world. International Crossfit competitions have been organized since 2007. According to the official website of Crossfit, many halls with more than 10,000 participants have been opened in 147 countries worldwide. In 2011, Reebok announced the CrossFit exercise system that improves aerobic and anaerobic performance and became its official sponsor (24).

With the spread of CrossFit in recent years, there has been a significant increase in high-intensity strength training (19,24). This has increased interest in gyms affiliated with the CrossFit company worldwide. According to American College Sports Medicine (ACSM) surveys, it has been one of the top 3 fitness trends worldwide since 2013 (25).

According to a 2018 study, more than 200,000 Crossfit athletes and over 11,000 CrossFit hall worldwide. The number of participants is increasing day by day (26). CrossFit continues to be the centre of attention and famous among participants of all ages in our country. The advent of CrossFit to Turkey is in the years 2011- 2012. As of 2020, there are 19 CrossFit halls in various provinces in our country.

2.1.2. The Characteristic Features of Crossfit Training

The CrossFit training is “constantly varied, high intensity, functional movement.”. Functional movements are defined by Greg Glassman; as motor recruitment patterning performed in waves of contraction from core to extremity over multiple joints. CrossFit training is a mix of Olympic weightlifting, powerlifting, sprints, plyometrics, callisthenics, gymnastics, and a few hard to categorize exercises like rope climbing. CrossFit is a method that believes that the most important and interrelated components of a fitness program, safety, benefit and impact, can only be supported by data that can be measured, observed and reproducible. This method, in which only the experimental method is used, is called “Proof Based Fitness” (1).

Crossfit workouts are high-intensity strengthening exercises. This exercise method involves fast and repetitive movements with little or no rest. In typical CrossFit exercises, athletes first perform warm-up training and then WOD. WODs vary from day to day. They are high-intensity exercise mixes that usually last between 5-20 minutes. Crossfit workouts are short (usually 20 minutes or less), intense and functional movements and constantly changing exercises (3, 5, 6).

2.1.3. Physiology of Crossfit Training

Recently, there has been an increase in fitness centres where high-intensity interval training (HIIT) is used instead of traditional endurance training (27). Recent studies have shown that HIIT improves health and fitness faster than traditional methods (28, 29, 30, 31). Crossfit is also a variant of HIIT (19). Crossfit WODs are a wide variety of exercises. The content of WODs includes running, rowing, Olympic lifting, gymnastic movements (32).

CrossFit training develops both aerobic and anaerobic endurance, strength, flexibility, power, speed, coordination, agility and balance in less time than other indoor sports. (9). Crossfit workouts have been shown to provide significant increases in cardiovascular response and fitness levels (4, 19, 33). HIIT improves aerobic and anaerobic fitness faster than traditional exercise methods(19).

2.2. General Physical Abilities that Crossfit Plans to Develop

Crossfit is a strength, strength, gymnastics and fitness-endurance program. CrossFit uses a wide variety of training methods. It has been said that CrossFit programs have been developed to increase the physical characteristics of individuals in all physical exercises. G. Glassman stated that Crossfit programs prepare athletes for all kinds of unknown and unpredictable physical conditions (9).

The Crossfit Program develops many general physical abilities. CrossFit training improves cardiorespiratory endurance (both aerobic and anaerobic endurance), endurance, strength, flexibility, power, speed, coordination, agility, and balance much faster than other indoor sports(8). Also, balance is a fundamental foundation for athletes participating in CrossFit (9).

2.2.1. Cardiorespiratory Endurance

The ability of the circulatory and respiratory systems to supply oxygen during prolonged physical exercises is called cardiorespiratory endurance. According to another definition, athletes generate energy fastest by burning their energy sources by oxidation (34).

Cardiorespiratory endurance depends on the person's physical mobility and daily habits, as well as being affected by age, gender, genetic structure, health status and body weight.

Cardiorespiratory endurance is one of the key achievements of CrossFit programs. It is thought that there is a relationship between cardiorespiratory endurance level and reducing the risk of high blood pressure, coronary heart diseases, obesity, diabetes and many other diseases (34). It has been proven by studies that people with good cardiorespiratory endurance adapt to special training conditions more quickly and get rid of health problems more quickly (35). Both aerobic and anaerobic exercises have been added to the training to improve the respiratory and circulatory characteristics of Crossfit athletes (19,36).

2.2.2. Stamina

The ability of the whole organism to resist fatigue in long-term sportive work and the ability to resist high-intensity work for a long time is called stamina (37).

Endurance is classified in different ways. One of these is referred to as aerobic endurance (long-term workouts) and is the ability to continue training at low intensity for long periods of time. Another type of endurance is expressed as the continuous repetition of anaerobic (high-intensity endurance training) high-intensity exercises (16). It has been stated that CrossFit training plans to increase both aerobic and anaerobic endurance (19, 36). Aerobic and anaerobic exercises are essential for cardiovascular functions. In aerobic exercises, it produces low and moderate energy within a certain period of time. Therefore, these studies are very important for almost all sports branches. Although CrossFit has a model that mostly works on the anaerobic system, it has been shown that it does not adversely affect the aerobic level of the athlete.

2.2.3. Strength

Crossfit is a type of high-intensity interval training. It has a wide range of functional exercises (4). It was initially developed for military training and has become popular in civil society over time. Crossfit workouts include high-intensity strengthening exercises. Regular CrossFit exercises have been shown to increase muscle strength (18).

2.2.4. Flexibility

Flexibility refers to the limit of movement of a joint or a joint-muscle group. Flexibility is influenced by the structure, shape, and type of a joint. The movement is performed by the relaxation of the muscle antagonist, which moves in the opposite direction while moving in the muscles agonist involved in the formation of a movement. If the antagonist muscle does not relax when it is desired to perform the movement, or there is a lack of intramuscular coordination causes the limitation of flexibility. Flexibility also varies depending on factors such as age, gender, race (21, 37). Crossfit training improves the trainer's flexibility level.

2.2.5. Power

Power, which is one of the essential parts of human performance, is defined physiologically as the capacity of the phosphocreatine energy system exhibited for the renewal of ATP. When we express it mechanically, power; is defined as generating the highest level of force over a certain distance as soon as possible (16,38). In all human movements, force and speed combine to generate power. The human's maximum power development capacity level is the most critical determinant of the capacity to produce strength. Power emerges as a result of the combination of force and speed. In CrossFit training, athletes have to do their WODs within the specified time. Also, exercises are done against resistance. In this way, their power develops (8).

2.2.6. Speed

Speed is the ability to make movements that are specific to a particular sports branch, to be able to perceive, decide, and react quickly to an unforeseen situation in connection with their techniques, and to react in the fastest way to the nervous-muscular system. A physically active asset's path per unit time is called "speed" (39). As athletes compete with time in CrossFit training, their speed improves (3,5,6).

2.2.7. Coordination

It is the ability of the body to perform a movement that it has not done before in a short period in different situations suitable and quickly. Coordination is a very complex feature; it is very closely related to a motoric feature such as speed, endurance, flexibility. Coordination plays an essential role in the implementation of tactical-technical movements in unexpected situations and environments (16).

2.2.8. Agility

It is expressed as the ability to quickly and accurately change body position from a specific body position to another. Movements such as stopping, moving and changing direction must be done very quickly and in a controlled manner (40). In CrossFit training, the variety of training and the fact that it is done against time increases agility.

2.2.9. Balance

Balance is the ability to maintain a state of stability in the body. It is protected by the dynamic integration of internal and external forces and environmental factors. It is a fundamental skill required to perform daily life activities, decreasing due to age and exposing the person to potential injury as they decrease (10, 11). In sports activities, balance plays an essential role in maintaining posture and executing assigned tasks due to the close relationship between engine performance capacity. Balance can be applied to a static state while standing on the support base (BoS = base of support) with minimal movement and to a dynamic state while applying a fixed stance and performance techniques. Therefore, both static and dynamic balance in sports is associated with performance enhancement (12).

Static balance is defined as the ability to control the movement of the centre of gravity within the support base under a given condition. It is the one obtained in a particular stop position. Dynamic balance is the ability to balance when moving or switching between positions. It is the one obtained on movement (9,11,12).

2.3. CrossFit Approaches

2.3.1. Crossfit and Sports Approach

Crossfit is a fitness and training program that provides interest and participation in the physically active population. It was originally developed for military training. It also attracted great attention between the civil population over time. Crossfit WODs are based on complex exercises combined with traditional cardiovascular exercises. These complex exercises include running, weightlifting (snatch, clean, jerk, squat, deadlift, press/push press, bench press), olympic gymnastics pull-ups, toes-to-bar, knees-to-elbows, lunges, muscle-ups, burpees, dips, gluteus-hamstring developer sit-ups, push-ups, rope climbs, handstand push-ups, pistols) and ballistic movements (1). Exercises are often combined with high-intensity workout routines. WODs are performed quickly, repetitively, and with limited or no recovery time between sets.

The key characterizing feature of Crossfit exercises is scalability. Scalability refers not only to progress in the load, but also to modifications to movements that involve high flexibility and skill. Through the use of these modifications, individuals of varying fitness levels ranging from beginner to advanced can participate in a similar training regimen, or the “workout of the day” (WOD). WODs are usually completed for time, sometimes with a time cap, or as many rounds of the exercise are completed as possible within a given period of time. Thanks to scalability, crossfit workouts can be exercised in groups. Athletes with different skill levels can experience WOD together. In this way, people who do crossfit establish more friendship bonds than people who do traditional exercise methods. In addition, this has been shown to increase people's Crossfit engagement and Crossfit effectiveness(41,42).

WODs that increase cardiovascular capacity, muscle strength and endurance are used in crossfit. WODs include aerobic and anaerobic exercises(43). Crossfit trainers do not perform certain press movements with the help of machines like traditional fitness practitioners. Instead, they train with free weights. . In typical crossfit exercises, athletes first perform warm-up training and then 'workout of day'(WOD). WODs vary from day to day. They are high intensity exercise mixes that usually last between 5-20 minutes. Crossfit workouts are short (usually 20 minutes or less), intense and functional movements and constantly changing exercises (3, 5, 6).

2.3.2. Crossfit and Sportman Approach

According to CrossFit, the athlete; is defined as a person who is skilled or trained in strength, balance, agility, flexibility and endurance. CrossFit sees fitness, health and sports as combined structures. Power, strength, cardiovascular and respiratory resistance, flexibility, endurance, coordination, agility and balance are equally important among both the best athletes in the world and an individual who has never played sports. It may differ due to the needs of an average individual and an Olympic athlete. The CrossFit method is based on a structure that directs practitioners to be athletes because athletes have more bone intensity than non-athletes, less chance of chronic heart disease, less probability of stroke and less likely to go into depression (21).

2.3.2.1. Crossfit and Professional Athletes

CrossFit develops 10 physical abilities to prepare professional athletes for the ultimate physical competitions. They are cardiorespiratory endurance (both aerobic and anaerobic endurance), stamina, strength, flexibility, power, speed, coordination, agility, proprioception and balance (8).

CrossFit trainers undergo a performance evaluation. They must demonstrate their coaching skills. CrossFit trainers are evaluated based on six criteria. These criteria are group management, seeing, teaching, correcting, presence and attitude, and demonstration. CrossFit provides certification classes for four levels of trainers to meet the demands (44,45).

2.3.2.2. Crossfit and Sedentary Individuals

The reasons for the need for basic biometric features for a sedentary individual and a professional athlete may differ, but the basic biometric features we previously mentioned for CrossFit have an essential place in both groups. Of course, there will be differences between the amount of weight an athlete uses in the exercises and the weight a sedentary individual uses. Functional movements in CrossFit need to ensure that health level is better. CrossFit is based on a system that guides individuals who practice the training philosophy to become athletes(45).

2.3.3. Crossfit and Training Approach

There is no standard workout in CrossFit workouts. The critical thing for CrossFit is to be ready for the unexpected. In order to come to this situation, it is necessary to be in constant variability and innovation and to organize training programs accordingly.

Each training method of CrossFit requires a plan in itself. According to CrossFit's understanding of training, each program aims to expand the warning as much as possible. It covers studies using long-term, medium-term, short-term metabolic conditions and low weights, medium-weights, and high-weights in CrossFit training. With such studies, it aims to force the athletes' psychological limits by leaving the brain under stress.

The main reason why CrossFit athletes perform so well is that their training does not adhere to a specific routine(21, 45).

2.3.3.1. Using Weightlifting Training and Olympic Lifts in the CrossFit Trainig

CrossFit uses shake and break movements, two different lifts of the Olympic barbell branch. Breakout technique; After the bar is caught with the arms, it is lifted over the head in a continuous and single motion. Shaking is a classic movement consisting of two parts as shoulder and shot. The athlete places his feet under the bar, parallel to each other and when viewed from above, see his feet in front of the bar. The shoulders, on the bar and slightly forward, the back is in a flat position, the knees bending from the knees, and the athlete grabs the bar to shoulder width or with a suitable opening. Following the straightness of the legs and body, the elbows forward turning it, the bar is blocked on the shoulders. Get up to the appropriate position for the shot. As a result of the violence applied to the bar with a sudden stretching from the knees, the legs are brought under the bar, which is moved upwards, by placing the legs in the scissors position. The bar is blocked on the head at a distance as long as the arm length by stretching the arms. With the legs straightened, the feet are brought together, and the movement is finished with a fixed posture(46).

Olympic lifts teach how muscle groups can use force in sequence. These lifts stimulate more muscle fibre and make the muscles work harder than other training models. This training results in a high explosive power ability. CrossFit uses back squat, clean, deadlift, front squat, overhead squat, presses, push jerk, push press, sumo deadlift high pull, snatch and thruster movements done with a barbell to support the technic and force development of shake-off and breakout movements to create an infrastructure. This creates a foundation for Olympic lifts and provides a wealth of practice for all levels.

CrossFit does not limit weightlifting training only to lifts with the Olympic bar. Tossing and throwing exercises with medicine balls, dumbbells and kettlebells are impressive stimuli in developing strength, strength, speed, coordination, agility, balance and body control. Many studies have shown that Olympic lifts uniquely provide strength, power, speed, flexibility, coordination, vertical bounce, stamina, increased bone density, and increased strength to withstand stress. In addition, shake-off and breakout movements significantly improve body control, balance and agility. In addition, in the CrossFit study model, Olympic lifts and other strength exercises with barbells are used to provide intense use of oxygen and the development of cardiorespiratory fitness levels (46).

2.3.3.2. Using Gymnastics in Crossfit Training

Gymnastics are methodical and regular exercises applied to improve the human body and spirit abilities(47). According to another definition, gymnastics is a branch that is done to strengthen our body with various exercises, where systematic and rhythmic movements are applied in coordination with body systems(48).

According to CrossFit, gymnastics is a branch that aim is to control the body with including climbing, yoga, physical education and dance. During gymnastics training, many features of the athlete develop, such as strength, speed, endurance, mobility, balance, rhythm, movement fluency (49).

CrossFit is used a wide variety of movements of gymnastics for the high athletic performance development. CrossFit allows the trainer to develop motor features such as muscle strength, muscle power, agility, flexibility, speed, muscle endurance and cardiovascular endurance by using one's body weight with using gymnastic motions like air squat, box jump, burpee, dip, GHD sit-up, back extension, handstand push-up, muscle up, pull-up, push-up, sit-up movements.

2.3.3.3. Using Interval Training in CrossFit Model

Interval training is the repetition of many exercise series at specific intervals. Feature of interval training is working and resting or systematic change of high and low load circuits (50).

During intermittent training, the person works with a predetermined method in which different loads are repeated, with a rest break during which the athlete cannot fully recover. The parts of the loads to be repeated are determined either by time or by distance. The primary determinant of resting time is heartbeat interval. In order to benefit from interval training in the most effective way, a person should combine the 3 interval methods given below (51).

- For anaerobic endurance; interval training with short loading is applied between 15 seconds and 2 minutes.

- To improve energy production systems; medium load interval training is applied between 2-8 minutes.

- To improve aerobic endurance; long-load interval training is applied between 8 and 15 minutes.

The basic rule in interval training is as follows; When the heart rate reaches 180-200 beats/minute, training is stopped, and when it drops to 120-130 beats/minute, it starts again. The points to be considered in interval training are the duration, scope and intensity of the study and rest (37).

According to CrossFit, the key to improving the cardiovascular system without losing strength, speed and power is interval training. Interval training mixes short periods of work and rest. The dominant metabolic pathway in a workout is determined by varying the number of repetitions, work and rest intervals. The CrossFit model divides interval training into 3 basic parts. The first is the phosphate pathway where 10-30 seconds of loads consisting of 25-30 repetitions are predominant, followed by 30-90 seconds of rest, and the load-rest ratio is 1/3. Second, 10-20 repetitions, 30-120 seconds of loads followed by 60-240 seconds of rest is the glycolytic pathway, where the load rest ratio is 1/2. The third is the oxidative pathway in which the resting ratio of 1/1 is dominant, by 120-300 seconds of loading from 3-5 repetitions, followed by 120-300 seconds of rest. CrossFit applies metabolic conditioning training as interval training (21).

a) Interval Training Terms

Interval Training: It is a part of interval training. It is a high work effort.

Interval Rest: The rest period between exercises or sets.

Interval Sets: They are defined work and rest series.

Repetitions: These are the interval exercises given in the set.

Training Time: The time elapsed between the start and completion of the workout.

Training Distance: It is the distance used in training.

Training Frequency: The number of training sessions per week.

b) Types of Interval Training

Training increases maximal working capacity (52). Physical training is beneficial only as long as it forces the body to adapt to high loads (53). Due to the physiological effects of interval training, there are forms of use in training plans according to the level of athletes. Interval training is evaluated in two main classes;

- Extensive Interval Training: This study is applied loads slightly above the lactate threshold to improve the aerobic energy system. This training method is also defined as threshold training, speed or tempo training (16). Extensive interval training workout intensity is low but continuous. The aim of this training is more endurance development. In general, the load intensity of extensive interval training should be done with 60-80% of the maximum load capacity. In elite athletes, the heart rate between repetitions is expected to decrease to 120-130 beats/minute (35). In order to achieve a significant improvement and physiological adaptation from extensive interval training, it is necessary to participate at least 2 times a week between 1 and 4 weeks (16).

- Intensive Internal Training: In this form of interval training, the working time is concise, and the intensity is above the maximal (16). In a study conducted with the intense interval training method, approximately 220 cm^3 of heart volume growth was achieved within a few weeks (54).

In general, with the interval training method, heart enlargement, aerobic and anaerobic capacity are improved (54). In addition, it aims to increase the oxygen intake capacity and improve essential endurance and motivation with extensive interval training. Intense interval training is; in addition to the development of special endurance and continuity in speed, the cardiovascular system can be developed in a short time (37).

c) Advantages of Interval Training Method

It has been observed that with interval training, significant improvements have been achieved in the level of health for sedentary individuals and physical performance for athletes in a short time. It is also stated that it can be an alternative to long endurance training. Repetitive use of ATP-PC stores is ensured with interval training. In this way, anaerobic glycolysis is not used much, which increases the training efficiency by providing the formation of muscle fatigue later than other methods. Adjusting the training time and rest forces both the anaerobic glycolysis and the oxygen transport system, allowing both systems to develop (52).

Interval training in the CrossFit model; It is used in various forms as it facilitates the control of the exercise intensity applied, allows the development to be seen easily, can be easily applied anywhere, the appropriate exercise can be selected for each branch, and it can be integrated into each branch (21).

d) Interval Training Methods Used in the Crossfit Model

According to CrossFit, high-intensity interval training improves instant aerobic capacity, anaerobic power and accordingly aerobic capacity (16). There are different methods and types of training used in CrossFit.

One of CrossFit's high-intensity interval training methods is the Tabata Method. The Tabata Method was developed as a result of a study conducted at Tokyo National Institute of Fitness and Sport in 1996 under the direction of Doctor Izumi Tabata. Olympic speed skaters practised it. According to the method, 20 seconds of ultra-intense exercise (approximately 170% max VO2) followed by 10 seconds of rest is performed continuously for 4 minutes (55).

Another high-intensity interval training method used in CrossFit is the RFT (Round for Time) or for time method. This method is a system based on completing the given movement group as soon as possible (56). Examples of WOD planned with the RFT method are shown below (57), (Table 2.1);

Table 2.1. WOD Planned with RFT Method

WOD1	WOD2
5 RFT 12 push press/12 pullup	4 RFT 400 m run/ 30 air squats

In the CrossFit model, the person competes with himself and others. WOD1 and WOD2 given above are study programs planned to create personal scores over the shortest time (55). There are unlimited combinations of programs available for CrossFit's time trials. One of the most well-known of these is the Fran Program. In the

Fran Program, 21 thrusters, 21 pull-ups, then 15 thrusters, 15 pull-ups, and finally 9 thrusters, 9 pull-ups are tried to be completed as quickly as possible (21,58).

In the CrossFit model, a time limit called time cap can be placed on round for time or for time exercises. Thus, CrossFit achieves its goal of high-intensity interval training. Below is a WOD with two different scores with a time limit (Table 2.2);

Table 2.2. WOD Planned with Time Limit

WOD3	WOD
10 min For Time Double Under 21 Box Jump 15 D.Snatch 12 Deadlift 9 Power Clean 6 HSPU 3 Power Clean 6 Deadlift 9 D. Snatch 12 Box Jump 15 Double Under21 Rep Pistol	6 Round For Time Time cap 14 min Burpee 5 Pull-up 10 Air Squat 20

The personal score for WOD3 is the number of repetitions to be performed in the 'rep pistol' movement in the remaining time after all movements have been performed. In WOD4, the maximum time to complete 6 sets is 14 minutes. If WOD has not been completed after 14 minutes, the work should be left in the number of sets. Failure assessment should be made, and the studies should be revised (21).

Another high-intensity interval training method is AMRAP (As Many Reps As Possible). In this method, athletes try to repeat the given number of repetitions and sets as many times as possible in a specific time (59). In the AMRAP system, personal records can be the number of repetitions of a move (WOD6) in some WODs, sometimes the total number of rounds (WOD5-7-9), sometimes the sum of two moves repetition

(WOD8), and sometimes the distance travelled (WOD10). Examples are given below (21), (Table 2.3) ;

Table 2.3. WOD Planned with AMRAP Method

WOD5	WOD6
12 min AMRAP 5 m climbing rope (2 rep) 20 Push-Up 100 double under	10 min AMRAP Pull-UP
WOD7	WOD8
7 min AMRAP 9 Front Squat (50/80 kg) 7 Burpee 5 Shoulder to Overhead	21 min AMRAP Firs 10 min Push-Up 1min Rest Last 10 min Squat
WOD9	WOD10
10 min AMRAP(stairs) Kettle Bell Swing (rep 1,2,3,...) Box Jumps (rep 1,2,3,...)	35 min running Every 5. min 15 Burpee

Another high-intensity interval training method CrossFit uses the EMOM (Every Minute on the Minute) method. In this method, the target number of repetitions is completed within 1 minute, and rest is given for the remaining time. With this method, the person's strength, endurance and quick recovery characteristics develop. Example WODs are given below (21, 60), (Table 2.4);

Table 2.4. WOD Planned with EMOM Method

WOD11	WOD12
10 min EMOM On Odd Minutes 20 Rep Kettlebell Swing On Even Minutes 12 Rep Burpee	14 min EMOM On Odd Minutes 6 Rep Front Squat On Even Minutes 50 Double Under

High-intensity interval training has resulted in significant improvements in physical performance for both sedentary and athletes in a short time (61).

2.4. Core Region and Crossfit Training

2.4.1. Definition of Core

The term core refers to the trunk or the lumbopelvic region of the body (62,63,64,65,66,67). The stability of the lumbopelvic region is vital to provide a base for movement of the upper and lower extremities, to support loads, and to protect the spinal cord and nerve roots(65). In sports, the term core is defined as the centre of gravity, which is considered the midpoint of the human body (68).

The core region can improve sportive performance in a variety of ways. The core region provides stabilization of the lumbopelvic region, which has an important place in applying of sporting techniques(69). This area is a tool that performs force transfer from the lower part of the body to the upper part of the body, and the muscles of the core region are directly involved when performing a movement (70).

The core region is the transition point of the balance of the movements of the extremities and force transfer. For this reason, the movements of the upper and lower extremities are considered as the motor centre (71). During motor movements, the core region has a supporting role in the movements of the extremities (72). For the exercises to be performed in a balanced, necessary intensity, with speed and strength, this region must be strong (71). The weakness of the core region muscles affects the sportive performance and causes postural disorders (73).

2.4.2. Core Musculature

Physical therapists define the core region as the diaphragm above, pelvic below, abdominal anteriorly, paraspinal and gluteal muscles posteriorly (74). The power created by the core region and the transmission (kinetic chain) plays a vital role in stabilizing the joints (lumbopelvic stability), especially in trunk rotation.

The literature has various functional and anatomical classifications regarding the core region muscles called lumbopelvic-gluteal. According to their functions, lumbosacral region muscles are classified as local and global (table 2.5), (75). Norris (1993), who increased the number of muscles belonging to the region in a similar classification, classified them as postural and phasic, that is, muscles related to strength with stabilizer. Those involved in stabilization from postural muscles are M. quadratus lumborum, M. multifidi, M. transversus abdominis, M. erector spinae, M. iliopsoas, M. tensor fascia latae, M. rectus femoris, M. priformis, M. pectineus, M. hamstring, M. gastrocnemius, M. soleus and M. tibialis posterior. Phasic muscles consist of M. rectus abdominis, M. obliquus abdominis imternus, M. obliquus abdominis externus, M. quadriceps, M. gluteal and M. tibialis anterior muscles, which are more effective in force production (76). In another classification made by Gibbons and Comerford (2001), global muscles are divided into global stabilization and global mobilization muscles (77). Willardson (2013) classified muscles according to the functions of local and global muscles (Table 2.6), and Faries and Greenwood (2007) classified them according to their position, speed, resistance and strength (Table 2.7), (78,79).

As global stabilizer muscles, M. semispinals, M. spinals and M. quadratus lumborum have the function of contraction at medium speed, producing moderate force, providing intersegmental connection, providing a joint range of motion in mid-depth, primarily concentric-eccentric movements. Global mobilization muscles such as the superficial abdominal muscles, M. sacrospinalis (M. longissimus iliocostalis), M. psoas major are superficial muscles. They function as a superficial muscle connected to the thorax and pelvis, which contracts rapidly and produces high torque (80).

Table 2.5. Classification of core muscles (Bergmark, 1988).

Local Muscles (Stabilization)		**Global Muscles (Mobilization)**
Primer Muscles	**Seconder Muscles**	
M. transversus abdominis	M. obliqus abdominis internus	M. rectus abdominis
M. Multifidus	M. obliqus abdominis externus (medial part)	M. obliqus abdominis externus (lateral part)
	M. quadtarus lumborum	M. psoas major
	Diaphragm	M. erector spinae
	Pelvic floor muscles	M. iliocostalis (Thoraks part)
	M. iliocostalis and M. longissimus (lumbar part)	

Table 2.6. Local and global muscles and their functions. (Willardson, 2013).

Global Core Stabilizers	
Muscle	**Primary Dynamic Function**
M. erector spinae	Trunk extension
M. quadratus lumborum	Trunk lateral flexion
M. rectus abdominis	Trunk flexion Posterior pelvic tilt
M. obliqus abdominis externus	Trunk lateral flexion Trunk Rotation
M. obliqus abdominis internus	Trunk lateral flexion Trunk Rotation
M. transversus abdominis	Pulling in the abdominal wall to maintain intra-abdominal pressure
Local Core Stabilizers	
Muscle	**Primary Dynamic Function**
M. multifidi	Trunk extension
M. rotatores	Trunk rotation
M. intertransversi	Trunk lateral flexion
M. interspinale	Trunk extension
Diaphragm	Increasing abdominal pressure
Pelvic floor muscles	Increasing abdominal pressure
Upper Extremity Core Muscles	
Muscle	**Primary Dynamic Function**
M. pectoralis major	Shoulder flexion Shoulder horizantal adduction Shoulder diagonal adduction
M. latissimus dorsi	Shoulder extansion and adduction Shoulder horizontal and diagonal abduction
M. pectoralis minor	Scapular depression
M. serratus anterior	Scapular protraction
M. rhomboideus	Scapular retraction
M. trapezius	Scapular elevation Scapular retraction Scapular depression
Lower Extremity Core Muscles	
Muscle	**Primary Dynamic Function**
M. iliopsoas	Hip flexion Pelvic anterior tilt
M. gluteus maximus	Hip extension Pelvic posterior tilt
M. hamstring	Hip extension Pelvic posterior tilt
M. gluteus medius	Hip abduction Pelvic lateral tilt

Table 2.7. Characteristics of local and global muscles. (Faries and Greenwood, 2007).

Local	Global
Deep	Superficial
They contract slowly	They conract fast
They have high endurance	They are effective at high powers
They are low powered	They are hihg powered
They are active at low resistances (Less than %40 density)	They are active at high resistances (More than %40 density)
Duration- dependent muscle activation	Strenght- dependent muscle activation

Local and global muscles contain two types of muscle fibers. These are fast-twitches and slow-twitches muscle fibers. The muscle fibers of the local muscular system (deep muscles)consist of slow-twitch muscle fibers. The length of these muscles is shorter than the global muscles. The primary tasks of these muscles are to control inter-regional movements, correct posture changes, respond to external loads, and ensure coordination. The muscle fibers of the global muscular system (superficial muscles) consist of fast-twitch muscle fibers. These muscles are long and have large branches. This way, they generate large movements and high amounts of torque movements (63).

2.4.3. Core Training and CrossFit Relationship

Core muscles have been described as a powerhouse for initiating limb movements. Core muscles are essential for postural control of the trunk, maintaining body position, staying stable in position changes, performing activities of daily living, and mobility function (81). Core stabilization transfers the optimum possible energy from the trunk to the extremities by controlling the position and movements of the trunk during a sportive movement (69).

Core stability positively affects sports performance. The relationship between the respiratory muscles and the core muscles in high-intensity running has been examined, and it has been stated that the fatigue in the core muscles as a result of insufficient work of the respiratory muscles affects the running performance negatively. In addition, core stability helps the individual stay in balance and maintain it. A correct posture and a strong core structure are essential for balance ability (21).

The performance displayed in the CrossFit model often depends on the resistance of the muscles in the core region during a sportive movement and the ability to maintain this resistance for a long time. The CrossFit model develops this performance component by creating unstable conditions during exercises and incorporating movements that require core stabilization into the programs (82).

2.5. Balance

Balance is defined as the ability to keep the body's centre of gravity within the limits of the support surface by using many sensory, motor and biomechanical components (83,84,85). It is the ability of body posture to stay in the desired position despite changing situations during static and dynamic movements (86,87,88,89).

Balance includes hip, knee and ankle joint movements controlled by coordinated movements along the kinetic chain (90,91,92). These movements are essential in creating the fluency of sports-related movements. Although balance is thought of as a static process, it is actually a dynamic process that includes many neurological pathways (86,92,93,94,95).

For the sustainability of the balance, the rapid rotational movements of the head and the three-dimensional positional position of the head in space are required, which is perceived by the semicircular canals in the ear, vestibular devices such as the utriculus and sacculus (95,96,97). In addition, afferent information from the eyes, such as keeping the head parallel to the ground and perceiving variable environmental conditions, must be correctly combined with proprioceptive input transmitted through the peripheral muscles, tendons, joints, ligaments, and skin (98). After all this information is collected, it is combined and harmonized at the cognitive level, and the correct movement, reaction, posture or physical response is formed through the musculoskeletal system (91,94,98).

It is known that balance plays a vital role in the successful display of many sportive skills and in changing direction, stopping, starting the activity, holding the ball or equipment specific to sports, moving the object or protecting the body in a certain position during sportive activities (86,89,92,93).

2.5.1. Static Balance and Dynamic Balance

There are two kinds of balance. These are Static balance and dynamic balance.

Static balance is automatically provided to maintain the general posture or body parts in a specific position at a stable support level and without the need for any external force (95). Macula receptors control the stability of the vestibular system membrane (99). The combination of forces acting on the body when moving from a stationary state tends to upset the existing static balance. In this case, dynamic balance control takes over (100)

Dynamic balance is the state of keeping the body's centre of gravity, which changes with the effect of external forces while in motion within the support surface (101). Dynamic balance can be thought to maintain or restore balance on an unstable surface with minimal external movement (102). In other words, dynamic balancing is the ability of the person to maintain the stability of the posture during movement (103). Dynamic balance is controlled by receptors in the semicircular canals that lead to rotational motions of the head (99).

2.5.2. Balance Systems

Maintaining balance requires the coordination of signals from multiple sensory systems. This balance occurs through the connection between the vestibular (auditory), visual, somatosensory (sensory), proprioceptive (positional), cognitive and musculoskeletal systems.

a) Vestibular System: The vestibular system is a sensory system responsible for maintaining spatial orientation and vision. It also provides information about balance reflexes by transmitting head acceleration and gravity impulses to centres associated with postural and ocular orientation in our body (104). The vestibular system has two types of vestibular organs. These are semicircular canals and otoliths. Otoliths are also of two types, saccular otoliths and utricular otoliths. Saccular otoliths detect vertical linear acceleration of the head. Utricular otoliths detect horizontal linear acceleration of the head. Semicircular canals detect rotational movements and angular acceleration. Also, the horizontal semicircular canals preserve the stability of the gaze (104, 105)

Various tasks of the vestibular system in the maintenance of postural control and balance. Some of these tasks are; sensing body position and own movement, bringing the trunk to a vertical position, controlling the position of the body's centre of mass with postural movements, and stabilizing the head during postural movements (105).

b) Visual System: The visual system receives information about the surrounding environment (106). Focal and ambient visions are components of the visual system. Local vision performs localizing features in the environment. Ambient vision is sensitive to movement (107). The visual system provides the strongest sensory support of the vestibular system. Thanks to this system, even if the vestibular system cannot fully perform its function, it can provide correction by seeing the body position thanks to the information coming from the visual fields (83,108-111).

c) Proprioceptive System: The literal meaning of proprio is information coming from inside the body. Such as the position of the joints, the strength in the muscles, the orientation in space. Kines means movement, and thesis means sense (89,112). Proprioception provides information about the musculoskeletal system related to general muscle tone and the position and movement of the body and limbs in space (113).

Proprioceptive receptors are found in many tissues such as skin, muscle, joint, tendon, ligament and capsule. It transmits information about temperature, pain, tension, pressure, balance, active and passive joint position sense and body position to the central nervous system by pacini, ruffini, Meissner, golgi tendon organ and muscle spindle, and provides the necessary responses (85,92, 112)

Muscle spindles are responsible for collecting information about muscle length and movement for the central nervous system (113). In addition, joint position sense and motion perception are produced by muscle spindles (114). The Golgi Tendon Organ (GTO) located in the muscle-tendon is another receptor that provides proprioceptive information to the central nervous system. It is sensitive to tensile forces, and when stimulated, the tension within the muscle and tendon is reduced (115). These senses are essential for motor control and function.

There are two levels of proprioception, conscious (voluntary) and subconscious. While conscious proprioception provides necessary and appropriate joint movement in physical activities, subconscious proprioception controls muscle function and provides reflexive balancing of joints through muscle sensors (92).

2.5.3. Balance and Crossfit

Cardiovascular/respiratory endurance, endurance, strength, flexibility, power, speed, coordination, agility, balance and accuracy are the ten general physical skills CrossFit is based on (15) coordination, agility, balance, and accuracy skills produce changes in the nervous system. These skills need to be applied to improve performance. Stability skills include axial skills (bending, lifting, pushing, etc.), springing movements (diving board, trampoline, vertical jumps, etc.), upright supports (symmetrical and asymmetrical balances, balance bar, joint stunts, etc.), and inverted supports (tripod, handstand, handstand, etc.), (116). The real-world practical application of these skills involve examples such as deadlifting groceries off the ground (axial), walking upstairs (springing movements), walking (upright supports), and handstands in a gymnastics class (inverted supports). Considering that each of these four areas can be seen in everyday life and a CrossFit workout, it appears balance is essential for participants of CrossFit (15).

3.MATERİAL AND METHOD

3.1. Subjects

The sample of the study consisted of 20 adult individuals who regularly do CrossFit training and 20 sedentary individuals. 10 female and 10 male adult individuals were included in both groups. A total of 40 participants were included in the study.

G power 3.1.9.4 (power analysis) program was used while calculating the sample size. As a result of the calculations, the sample was formed by selecting 10 male and 10 female athletes (25-40 years old) who received Crossfit training for at least 6 months in the case group, and 10 male and 10 female sedentary individuals (25-40 years old) who did not do sports for at least 6 months in the control group. A total of 40 volunteer participants were recruited. The type of study is the Cross-Sectional Study. Research is quantitative.

Adult individuals who regularly practiced CrossFit for at least 6 months were included in the CrossFit Training Group (CTG), while individuals who did not participate in any exercise program were included in the Sedentary Group (SG).

3.1.1. Inclusion Criteria

Individuals who met the following inclusion criteria participated in the study.

- be between the ages of 25-40
- People who have not had an operation on the lower extremity in the last 1 year
- Individuals who have not had a muscle or joint injury in the lower extremity in the last three months
- Individuals whose body mass index value is within the normal range (18.5-24.9)
- For the Case Group; Regular CrossFit training at least 3 days a week for the last 6 months be taking
- For the control group; Male and female participants who have not done sports for at least 6 months

3.1.2. Exclusion Criteria

Individuals with the following exclusion criteria did not participate in the study.

- People who have had an operation on the lower extremity in the last 1 year
- People who have had muscle and joint injuries in the lower extremity in the last three months
- Individuals whose body mass index value is not within the normal range (18.5-24.9)
- Presence of a neurological disorder affecting balance (Parkinson's disease, Multiple Sclerosis etc.)
- Individuals with a diagnosed disease (cancer, psychological disorder) that may interfere with the study protocol

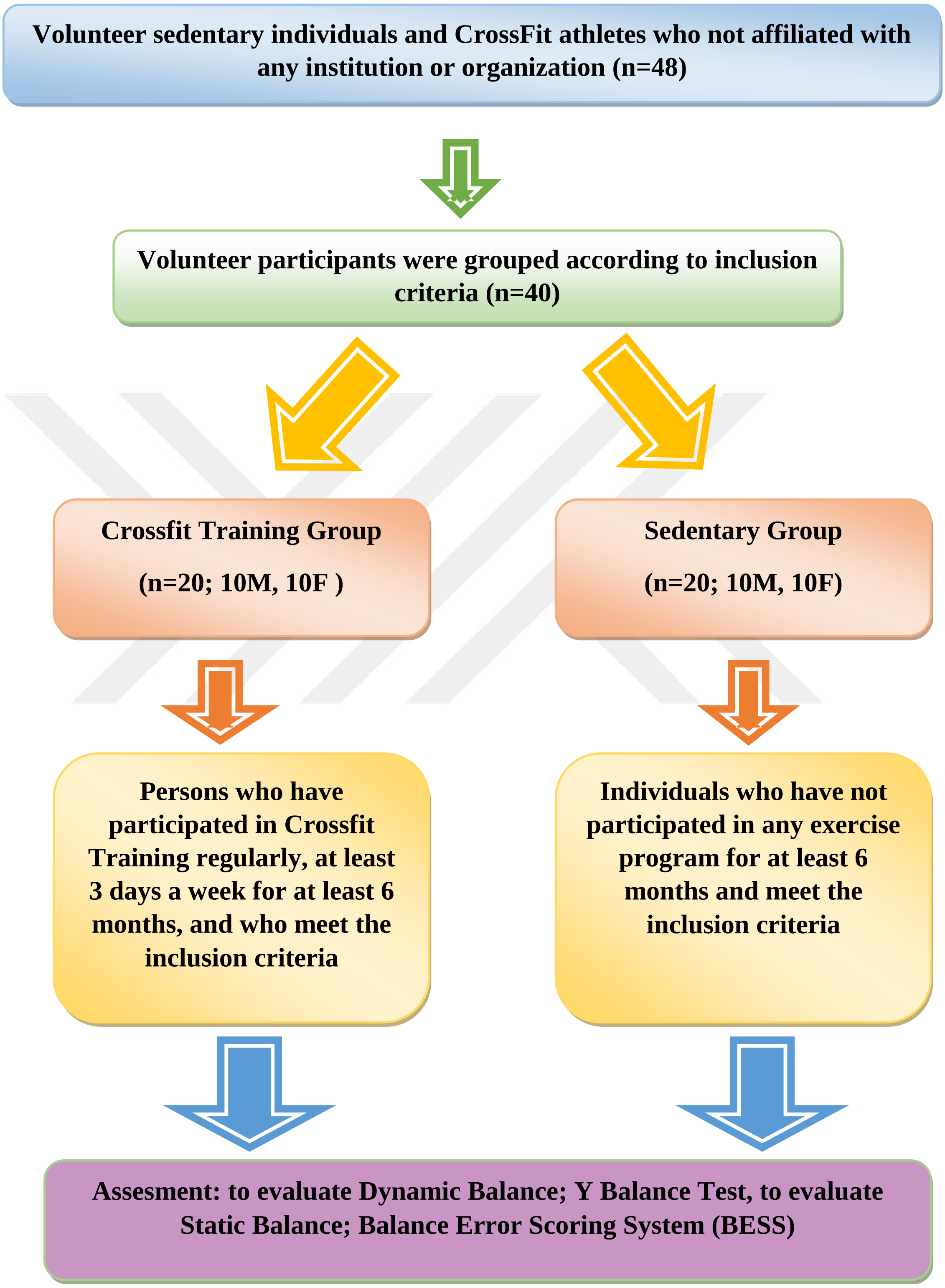
The study protocol was approved by the Marmara University Ethics Committee on 13.07.2020 and number 55 (Appendix 1). Participants participated in the research voluntarily. The purpose and plan of the study were explained to the participants in written and verbal form (Appendix 2), and written consent was obtained from each participant (Appendix 3). The study was conducted in accordance with the Declaration of Helsinki.

3.1.3. Flow Chart: Study Process

A total of 48 people were included in the preliminary evaluation. Three of the participants were excluded from the study due to lower extremity injuries in the last 3 months. Two participants were excluded from the study because their body mass index was outside the normal values. Since the age range of 3 participants was outside the desired age range, they were excluded from the study. After evaluation tests, a total of 40 adult subjects for CTG and SG, according to the inclusion criteria, participated in the study. We asked our participants if they would like to volunteer in our study. Individuals (n=40) who met the inclusion criteria were included in our study. After completing the initial assessment, people who regularly performed CrossFit exercise for at least 6 months (n=20; 10M, 10F) were placed on CTG, and sedentary individuals who did not exercise for at least 6 months (n=20; 10M, 10F) were placed on SG. The number of male and female participants in the groups was determined equally.

In our study, no intervention was made in either group. The people in the CrossFit training group were selected from those who had already started CrossFit at least 6 months ago and participated in CrossFit training at least 3 days a week. Static and dynamic balance assessment was made between these two groups.

Table 3.1 : Flow Chart of the study



3.1.4. Study Protocol

In the study, 20 volunteers who did not do any sports were included in the SG. On the other hand, 20 volunteer athletes who regularly practised CrossFit at least 3 days a week for at least 6 months were included in the CTG. Individuals in CTG were selected from individuals who participated in CrossFit workouts determined by their trainers. There was no external intervention in either group.

3.2. Evalation

3.2.1. Structured Questionnaire

A structured questionnaire was prepared by researchers and administered face to face. It includes questions about name, age, gender, socio-demographic conditions, existing chronic diseases, surgical conditions, injuries and type of sports, and how long they have been doing sports (Appendix 4).

3.2.2. Y-Balance Test(YBT)

The dynamic balance of both groups was evaluated with the Y-Balance Test, which combines three lines. Y Balance Test is developed by modifying the Star Excursion Balance Test (SEBT). This test was applied to both lower extremities. Y Balance Test consists of three aspects; anterior(A), posteromedial(PM), posterolateral (PL), (Figure 3.1). First, the dominant leg (defined as the dominant leg used for kicking) is placed in the middle of the platform. While the participants were on one leg, they tried to reach as far as possible with their other feet along the determined line. Then they retract their feet and spun on two legs. To decide whether the test should be performed clockwise or counterclockwise, it was checked whether the dominant leg of the participants was right or left. Participants were instructed to keep their hands on the iliac crest bones. They were told not to lift the heels of their feet off the ground. During test, reach distances were recorded as the distance from the centre of the platform to the maximum access point. (Figure 3.2) The test was repeated 3 times, and a average of 3 scores was taken. Leg length was measured from the anterior superior iliac spine (ASIS) to the medial malleolus tibia. The percentage of maximum reach to leg length ratio was taken (APPENDIX 5), (117).

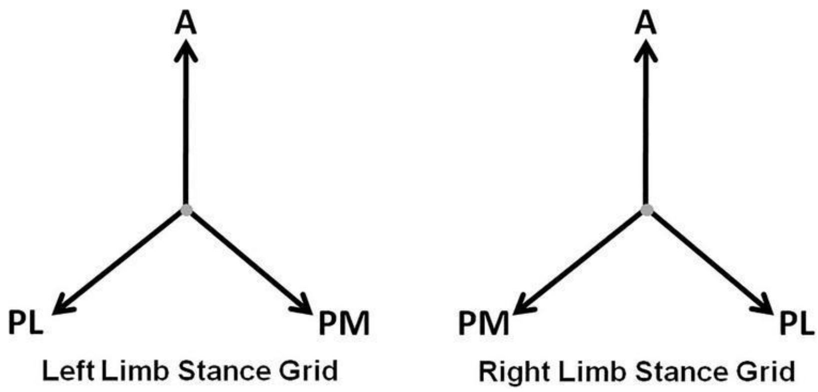


Figure 3.1. Three aspects of Y Balance Test; anterior(A), posteromedial(PM), posterolateral (PL)

a) Anterior b) Posteromedial c)Posterolateral

Figure 3.2. Y Balance Test (a, b, c)

3.2.3. Balance Error Scoring System (BESS):

The Balance Error Scoring System (BESS) was used to measure the static balance of both groups. BESS is a valid and reliable method for measuring postural stability. (118,119) BESS measures the athlete's postural stability and is scored by counting the mistakes that the athlete has made during the tests. BESS was preferred for evaluation because it is not expensive and requires less training for effective application (118). This clinical balance test was performed using only a stopwatch and a 10 cm thick medium density foam. The test is for a total of six trials, once on a hard surface and once on foam; It was done with three different stances (double, single and tandem) that were completed twice. Athletes took the necessary stance by placing their hands on the iliac crest, and after the eyes were closed, the 20-second test began. In the double-leg stance, the two feet were positioned side by side to completely touch each other. During the single-leg stance, subjects were asked to keep the opposite limbs at 20-30° hip flexion and 40-50° knee flexion. In addition, the athletes were asked not to separate their hands from the iliac wing and keep their eyes closed and to remain as quiet and still as possible in the stance. Single limb stance tests were performed on the non-dominant foot. The same foot was placed backwards in tandem stances. Subjects were instructed to make the necessary adjustments and return to the test position as soon as possible when they lost their balance. (Figure 3.3). Performance was scored such that each error made was recorded. Errors are written on the BESS scorecard (Figure 3.4), (Errors: hands raised from the iliac wing, opening eyes, stepping or falling, hip flexion or abduction more than 30°, forefoot or heel lift.) deemed to be missing. The standard maximum error score of “10” was assigned to these trials (APPENDİX 5).

Figure 3.3. Balance Error Scoring System

Score Card

Balance Error Scoring System (BESS)
(Guskiewicz)

Balance Error Scoring System – Types of Errors
1. Hands lifted off iliac crest 2. Opening eyes 3. Step, stumble, or fall 4. Moving hip into > 30 degrees abduction 5. Lifting forefoot or heel 6. Remaining out of test position >5 sec
The BESS is calculated by adding one error point for each error during the 6 20-second tests.

SCORE CARD: (# errors)	FIRM Surface	FOAM Surface
Double Leg Stance (feet together)		
Single Leg Stance (non-dominant foot)		
Tandem Stance (non-dom foot in back)		
Total Scores:		
BESS TOTAL:		

Which **foot** was tested: ☐ Left ☐ Right
(i.e. which is the **non-dominant** foot)

Figure 3.4. BESS Score Card

3.3. CrossFit Training Programs (WODs)

Participants who met the inclusion criteria were included in either CTG or SG. All participants were evaluated with the Y-Balance Test and Balance Error Scoring System. There was no external intervention in either group. Participants in SG did not participate in any exercise program. Athletes at CTG were selected from those who participated in CrossFit training programs named WOD as determined by their trainers.

RFT (or for Time), AMRAP, EMOM training types, which are the polar methods of CrossFit WODs, have been performed by the people in the CrossFit group for at least 6 months and at least three times a week.

RFT training method is against time. It aims to complete the given plan within the specified time. In Crossfit training, people compete with themselves and others. In the RFT training method, the winner is the person who finishes the training in the shortest time. These workouts have a time limit called the time cap. Therefore, if the training is not completed within the specified time, it is stated that the task cannot be completed.

AMRAP stands for "As many reps or rounds as possible". In this system, it is aimed to perform the given movements as much as possible in the given minute.

EMOM: Abbreviation for "Every minute on the minute". Here the target given at the beginning of each minute is done, and the rest is rest. So 10 minutes EMOM: 2 power snatches, 2 overhead squats can be an exemplary workout. What needs to be done here is 2 power snatches and 2 overhead squats at the start of every minute. If this complex is completed within 10 seconds, the rest of the minute, 50 seconds, is the time left for the person to rest. (21,57,59,60).

In our study, instead of giving exercises to the Crossfit training group, we included people who have already started CrossFit at least 6 months ago and participated in training sessions that meet the above conditions at least 3 days a week. The some of CrossFit WODs that the athletes participated in are given in the table below (Table 3.2), (Table 3.3), (Table 3.4).

Table 3.2. CrossFit WODs Planned with AMRAP that the Athletes Participated in

WOD 1	AMRAP in 20 min (CİNDY) 5 Pull-Ups 10 Push-Ups 15 Air Squats
WOD 2	10 min AMRAP Pull-UP
WOD 3	7 min AMRAP 9 Front Squat (50/80 kg) 7 Burpee 5 Shoulder to Overhead
WOD 4	10 min AMRAP(stairs) Kettle Bell Swing (rep 1,2,3,...) Box Jumps (rep 1,2,3,...)

Table3.3. CrossFit WODs Planned with EMOM that the Athletes Participated in

WOD 5	10 min EMOM On Odd Minutes 20 Rep Kettlebell Swing On Even Minutes 12 Rep Burpee
WOD 7	14 min EMOM On Odd Minutes 6 Rep Front Squat On Even Minutes 50 Double Under
WOD 8	25 min EMOM Min1 : 18 Calorie Row Min2 : Plank Min3 : 15 Burpees Min4 : 50 Double unders Min5 : Rest (repeat)

Table 3.4. CrossFit WODs Planned with RFT that the Athletes Participated in

WOD 9	For Time 21 body-weight back squats 7 rope climbs, 15-ft. rope 15 body-weight back squats 5 rope climbs, 15-ft. rope 9 body-weight back squats 3 rope climbs, 15-ft. rope
WOD 10	50-40-30-20-10 RFT Double-unders Sit-ups
WOD 11	5 RFT 12 push press 12 pull-up
WOD 12	4 RFT 400 m run 30 air squats
WOD 13	6 RFT (Time cap 14 min) Burpee 5 Pull-up 10 Air Squat 20

3.3.1. Explanation of Movements in Example WODs

a) Pull-Up: In this exercise, the person holds a fixed bar called a barfix and pulls the body mass upwards towards the bar. The head passes the bar a little and returns to the starting position (120,121), (Figure 3.5).

b) Push-Up: While performing the push-up movement, the athlete's body should be in a straight line from head to toe. The hands should be shoulder-width apart in a position suitable for the movement, and the palms should touch the ground with the fingers. While the body is descending, the elbow joint should make an angle of 90 degrees, and in the ascending phase, the elbow joint should be completed when it is straight (122), (Figure 3.6).

c) Air Squat: To execute the movement, the athlete begins by moving his or her hips down and back (versus moving the knees forward). The athlete descends until the hip crease is below the kneecap while keeping the knees over the feet and the spine neutral. The movement is finished when the athlete returns to the full upright position with the hips and knees extended(123), (Figure 3.7).

d) Back Squat: The correct way to do parallel back squats is to make the segment torso as straight as possible to minimize the forces that the lumbar spine can support. The feet should be spread at shoulder level. The bar should be placed firmly on the shoulders, gripped from the sides to put more pressure on the bar and prevent the back from crooked, creating an undesirable effort on the lumbar spine (124), (Figure 3.8).

e) Front Squat: In the front squat, the bar is held up on clavicles and the superior part of the chest, with the elevated elbows towards the front and with the most erect trunk, preventing the risk of fall of the bar towards ahead (124), (Figure 3.9).

f) Burpee: In quick succession, Burpees involve crouching, push-ups, and vertical jumps (Figure 3.10).

g) Shoulder to Overhead: The Shoulder-to-Overhead is an upper-body vertical pushing movement designed to get a load from the shoulders to the overhead position in the most efficient way possible (Figure 3.11).

h)Kettle Bell Swing: Correct alignment is maintained between the back of the head and the C8 and sacral vertebrae during the swing exercise. The movement is initiated by loading the hamstrings and “packing” the shoulders (maintaining a neutral shoulder girdle) by driving the hips back in a "hip-hinging" motion. The movement is then strongly reversed to bring the hips and therefore the kettlebell forward. The kettlebell should be displaced vertically between hip and shoulder height, depending on its weight. The swing exercise should continue until the perceived "crispness" of the movement begins to wane. (125), (Figure 3.12).

i) Box Jumps: While facing the box, jump on the box using your legs. Come to an upright position on the box and provide hip stretch. Then return to the starting position again (Figure 3.13).

j) Calorie Row: Sit on the sitting platform of the machine and lean against the chest support cushion of the chest table. The hand is held by the machine's handles and is pulled towards the body by exhaling. Here it wait for 1 second, and then when the hands are at chest level, they are released slowly by breathing (Figure 3.14).

k) Plank: Carrying the trunk to create a straight line between the shoulders and feet while on the wrists in the prone position (Figure 3.15).

l) Sit-Ups: It is a classic abdominal exercise performed by lying on your back and lifting your torso forward (Figure 3.16).

m) Push Press: Feet open at shoulder level. The hips and knees are slightly bent while the torso is standing upright. The weight should be above the chest at shoulder level with the knees bent. Immediately after the twisting movement, the weight is lifted upwards. The torso is kept upright and stretched. During lifting, the barbell is pushed upwards from the shoulders. Elbows are brought to the upright position (Figure 3.17).

Figure 3.5. Pull-Up

Figure 3.6. Push-UP

Figure 3.7. Air Squat

Figure 3.8. Back Squat

Figure 3.9. Front Squat

Figure 3.10. Burpee

Figure 3.11. Shoulder to Overhead

Figure 3.12. Kettlebell Swing

Figure 3.13. Box Jumps

Figure 3.14. Calorie Row

Figure 3.15. Plank

Figure 3.16. Sit-Ups

Figure 3.17. Push Press

3.4. Statistical Analysis

Statistical Package Analyze for Social Sciences (SPSS) version 22.0 was used to analyze the data obtained from the study and to create the tables. Data on variables such as age, height, body weight, and participants' body mass index will be analyzed descriptively. The Kolmogorov-Smirnov test was used to test the numerical variables for normality. Differences in test results between groups (CTG and SG) were determined by Independent Samples T-Test for parametric variables. The significance level was accepted as $p<0.05$.

4. RESULTS

A total of 40 volunteer participants (25-40 years) were included in the study between June 2021 and September 2021.

The physical characteristics (age, weight, height and body mass index (BMI)) of CTG and SG are presented in Table 4.1. Comparing the two groups, the physical characteristics of the participants showed that there was no significant difference in terms of age, weight, height and BMI according to the independent sample t-test results (p>0.05).

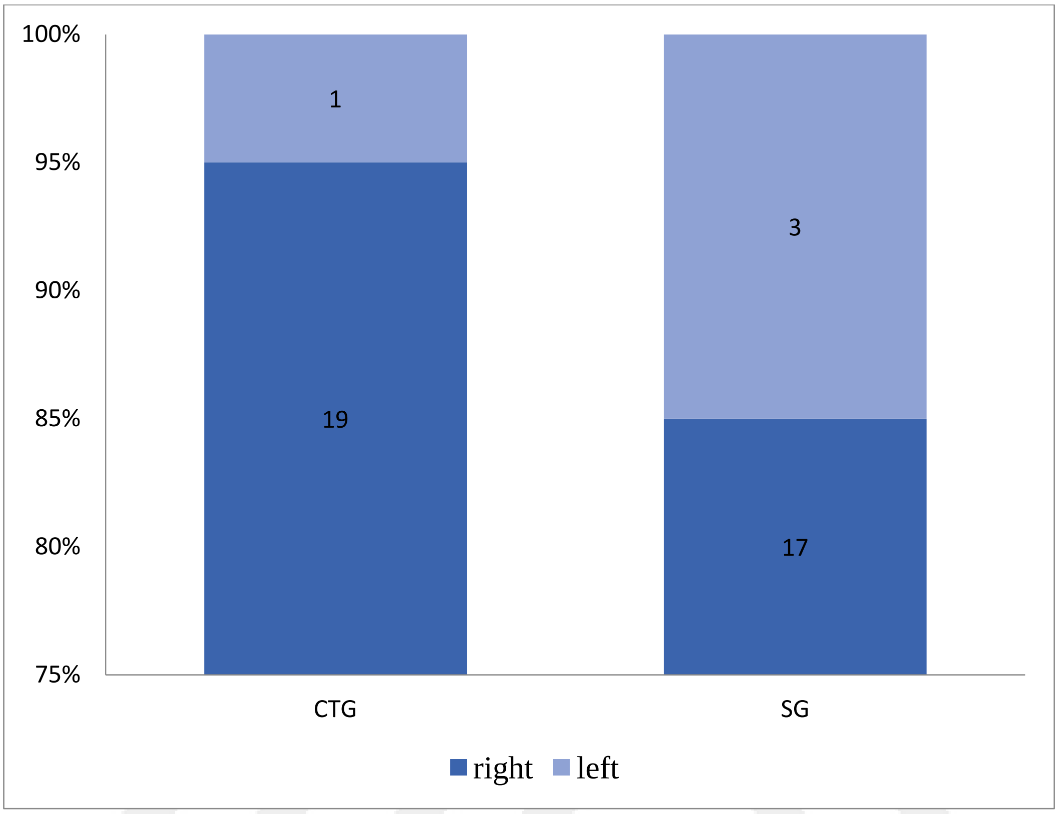
Table 4.1. Physical Features of Participants

	CTG	**SG**	**t p value**
Age (year)	30.95±4.48	30.20±4.46	-0.53 0.59
Weight (kg)	67.55±11.11	65.75±9.15	-0.55 0.57
Height (m)	172.90±10.10	172.50±8.67	-0.13 0.89
BMI (kg/ m²)	22.44±1.71	22.01±1.83	-0.75 0.45

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. kg:kilogram. m: meter. BMI: Body mass index. CTG: CrossFit Training Group, SG: Sedentary Group.

The dominant leg distribution of the study groups is shown in Graph 1. Of the 40 participants included in the study, 36 (90%) were right-leg dominant and 4 (10%) left-leg dominant. Among the participants in the CTG, 19 participants were right leg dominant, 1 participant was left leg dominant. The dominant foot of the 17 participants in the SG is the right and the dominant foot of the 3 participants is the left.

Figure 4.1. The Number and Percent of Dominant Leg of The Participants



Bar Chart shows the number of dominant legs of the participants. CTG: CrossFit Training Group, SG: Sedentary Group.

Before the evaluations, when the data distribution was examined using the Kolmogorov-Smirnov test for CTG and SG, it was observed that there was a normal distribution. Therefore, an independent-samples t-test was used to compare the dynamic and static balance values of CTG and SG ($p<0.05$).

Table 4.2. Comparison of Y Balance Test Variables between CTG and SG

			CTG	SG	p value
Y-Balance Test	A (%cm)	Right	91.75±8.26	81.91±16.37	**p= 0.02,** t: -2.39
		Left	92.95±8.89	81.59±17.89	**p= 0.01,** t: -2.54
	PM (%cm)	Right	93.99±9.67	83.44±17.15	**p= 0.02,** t: -2.39
		Left	90.98±11.80	82.35±14.7	**p= 0.04,** t: -2.04
	PL (%cm)	Right	89.87±9.66	81.53±13.18	**p= 0.02,** t: -2.28
		Left	88.93±10.81	80.89±13.36	**p= 0.04,** t: -2.09

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. A=Anterior , PM=Posteromedial , PL=Posterolateral cm:centimetres. CTG: CrossFit Training Group, SG: Sedentary Group.

The Kolmogorov-Smirnov test was used to test the numerical variables for normality, and it was determined that the distribution of test results was normal. For this reason, Independent-Samples T-Test was used for parametric values.

The Relative (normalized) reach distance (%cm) used for the Y-Balance Test was calculated as follows:

$$\text{The Relative(normalized) reach distance(\%cm)}= \left(\frac{\text{Absolute reach distance}}{\text{Leg length}} \right) \text{x } 100$$

(124).

Comparing measurement findings of the Y-Balance Test were showed that both groups had differences in A-Right and Left, PM-Right and Left, PL-Right and Left parameters ($p<0.05$). It means that participants in CTG had a better dynamic balance than participants in SG in these results (Table 4.2).

Table 4.3. Comparison of Balance Error Scoring System Variables between CTG and SG

	CTG	**SG**	**p value**
DLSHF	0.10±0.30	0.30±0.47	p= 0.12, t: 1.59
SLSHF	1.70±0.65	1.85±1.08	p= 0.6, t: 0,52
TLSHF	0.80±0.61	1.60±1.35	**p= 0.02,** t: 2.4
DLSSF	0.80±069	1.75±1.61	**p= 0.02,** t: 2.41
SLSSF	2.6±0.94	4.9±1.97	**p= 0.00,** t: 4.71
TLSSF	1.75±096	3.0±1.21	**p= 0.00,** t: 3.6
TSHF	2.60±1.27	3.75±2.65	p= 0.08, t: 1.74
TSSF	5.15±2.41	9.65±4.36	**p= 0.00,** t: 4.03
BESST	7.75±3.38	13.40±6.54	**p= 0.00,** t: 3.42

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants.BESS= Balance Error Scoring System, DLSHF= Double Leg Stance on Hard Floor, SLSHF=Single Leg Stance on Hard Floor, TLSHF=Tenden Leg Stance on Hard Floor, DLSSF= Double Leg Stance on Soft Floor, SLSSF=Single Leg Stance on Soft Floor, TLSSF=Tendem Leg Stance on Soft Floor, TSHF= Total Scor on Hard Floor, TSSF=Total Scor on Soft Floor, BESST= Balance Error Scoring SYSTEM Total. CTG: CrossFit Training Group, SG: Sedentary Group.

The Kolmogorov-Smirnov test was used to test the numerical variables for normality, and it was determined that the distribution of test results was normal. For this reason, Independent-Samples T-Test was used for parametric values.

Comparing measurement findings of the Balance Error Scoring System were showed that both groups had differences on TLSHF, DLSSF, SLSSF, TLSSF, TSSF, BESST($p<0.05$), but there was no statistical difference among DLSHF, SLSHF, TSHF. It means that participants in CTG had better static balance than participants in SG in some results (Table 4.3).

Table 4.4. Comparison of Y Balance Test Variables between in Male

			CTG	**SG**	**p value**
Y-Balance Test	A (%cm)	Right	95.32±8.02	86.05±15.13	p= 0.1, t: -1.71
		Left	95.78±8.80	85.07±17.57	p= 0.1, t: -1.72
	PM (%cm)	Right	94.16±8.62	89.0±19.23	p= 0.44, t: -0.77
		Left	93.61±11.47	88.60±14.25	p= 0.39, t: -0.86
	PL (%cm)	Right	92.68±8.97	84.03±14.35	p= 0.12, t: -1.61
		Left	91.15±9.91	84.07±16.43	p= 0.25, t: -1.16

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. A=Anterior , PM=Posteromedial , PL=Posterolateral cm:centimetres, CTG: CrossFit Training Group, SG: Sedentary Group.

The Kolmogorov-Smirnov test was used to test the numerical variables for normality, and it was determined that the distribution of test results was normal. For this reason, Independent-Samples T-Test was used for parametric values.

When the Y-Balance Test measurement findings were compared, it was seen that there was no difference in dynamic balance parameters of males in CTG and males in SG (Table 4.4).

Table 4.5. Comparison of Y Balance Test Variables in Female

			CTG	**SG**	**p value**
Y-Balance Test	A (%cm)	Right	88.18±7.18	77.77±17.29	p= 0.1, t: -1.75
		Left	90.12±8.48	78.12±18.45	p= 0.08, t: -1.86
	PM (%cm)	Right	93.82±11.1	77.89±13.52	**p= 0.01,** t: -2.87
		Left	88.34±12.12	76.09±12.89	**p= 0.04,** t: -2.18
	PL (%cm)	Right	87.05±9.95	79.02±12.11	p= 0.12, t: -1.61
		Left	86.71±11.72	77.71±9.21	p= 0.07, t: -1.9

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. A=Anterior , PM=Posteromedial , PL=Posterolateral cm:centimetres. CTG: CrossFit Training Group, SG: Sedentary Group.

The Kolmogorov-Smirnov test was used to test the numerical variables for normality, and it was determined that the distribution of test results was normal. For this reason, Independent-Samples T-Test was used for parametric values.

Comparing measurement findings of the Y-Balance Test between female participants in CTG and SG were showed that both groups had differences in PM-Right and Left ($p<0.05$), but there was no difference in other dynamic balance parameters of female participants in CTG and SG (Table 4.5).

Table 4.6. Comparison of Y Balance Test Variables between Male Participants and Female Participants in CTG**.**

			Male in CTG	**Female in CTG**	**p value**
Y-Balance Test	A (%cm)	Right	95.32±8.02	88.18±7.18	p= 0.05, t: -2.09
		Left	95.78±8.80	90.12±8.48	p= 0.16, t: -1.46
	PM (%cm)	Right	94.16±8.62	93.82±11.1	p= 0.94, t: -0.07
		Left	93.61±11.47	88.34±12.12	p= 0.33, t: -0.99
	PL (%cm)	Right	92.68±8.97	87.05±9.95	p= 0.20, t: -1.32
		Left	91.15±9.91	86.71±11.72	p= 0.37, t: -0.91

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. A=Anterior , PM=Posteromedial , PL=Posterolateral cm:centimetres. CTG: CrossFit Training Group.

The Kolmogorov-Smirnov test was used to test the numerical variables for normality, and it was determined that the distribution of test results was normal. For this reason, Independent-Samples T-Test was used for parametric values.

When the Y-Balance Test measurement findings were compared, it was seen that there was no difference in dynamic balance parameters of male and female athletes (Table 4.6).

Table 4.7. Comparison of Balance Error Scoring System Variables in Male

	CTG	SG	p value
DLSHF	0.0±0.0	0.30±0.48	p= 0.06, t: 1.96
SLSHF	1.50±0.70	2.10±0.99	p= 0.13, t: 1.55
TLSHF	0.70±0.67	1.90±1.44	**p= 0.02,** t: 2.37
DLSSF	0.70±0.67	2.10±1.85	**p= 0.03,** t: 2.24
SLSSF	2.30±0.82	4.60±2.36	**p= 0.01,** t: 2.90
TLSSF	1.50±0.97	2.80±1.22	**p= 0.01,** t: 2.62
TSHF	2.20±1.13	4.30±2.66	**p= 0.03,** t: 2.29
TSSF	4.50±2.17	9.50±5.21	**p= 0.01,** t: 2.80
BESST	6.70±2.94	13.80±7.49	**p= 0.01,** t: 2.78

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. BESS= Balance Error Scoring System, DLSHF= Double Leg Stance on Hard Floor, SLSHF=Single Leg Stance on Hard Floor, TLSHF=Tenden Leg Stance on Hard Floor, DLSSF= Double Leg Stance on Soft Floor, SLSSF=Single Leg Stance on Soft Floor, TLSSF=Tendem Leg Stance on Soft Floor, TSHF= Total Scor on Hard Floor, TSSF=Total Scor on Soft Floor, BESST= Balance Error Scoring System Total. CTG: CrossFit Training Group, SG: Sedentary Group.

The Kolmogorov-Smirnov test was used to test the numerical variables for normality, and it was determined that the distribution of test results was normal. For this reason, Independent-Samples T-Test was used for parametric values.

Comparing measurement findings of the Balance Error Scoring System were showed that male participants in both groups had differences on TLSHF, DLSSF, SLSSF, TLSSF, TSHF, TSSF, BESST($p<0.05$), but there was no statistical difference among DLSHF, SLSHF. It means that male participants in CTG had better static balance than male participants in SG in some results. (Table 4.7).

Table 4.8. Comparison of Balance Error Scoring System Variables in Female

	CTG	SG	p value
DLSHF	0.20±0.42	0.30±0.48	p= 0.62, t: 0.49
SLSHF	1.90±0.56	1.60±1.17	p= 0.48, t: -0.72
TLSHF	0.90±0.56	1.30±1.25	p= 0.37, t: 0.92
DLSSF	0.90±0.73	1.40±1.35	p= 0.31, t: 1.02
SLSSF	2.9±0.99	5.20±1.54	**p= 0.00,** t: 3.95
TLSSF	2.0±0.94	3.2±1.22	**p= 0.02,** t: 2.44
TSHF	3.00±1.33	3.20±2.65	p= 0.83, t: 0.21
TSSF	5.8±2.57	9.8±3.61	**p= 0.01,** t: 2.85
BESST	8.80±3.61	13.0±5.83	p= 0.06, t: 1.93

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants.BESS= Balance Error Scoring System, DLSHF= Double Leg Stance on Hard Floor, SLSHF=Single Leg Stance on Hard Floor, TLSHF=Tenden Leg Stance on Hard Floor, DLSSF= Double Leg Stance on Soft Floor, SLSSF=Single Leg Stance on Soft Floor, TLSSF=Tendem Leg Stance on Soft Floor, TSHF= Total Scor on Hard Floor, TSSF=Total Scor on Soft Floor, BESST= Balance Error Scoring System Total. CTG: CrossFit Training Group, SG: Sedentary Group.

The Kolmogorov-Smirnov test was used to test the numerical variables for normality, and it was determined that the distribution of test results was normal. For this reason, Independent-Samples T-Test was used for parametric values.

Comparing measurement findings of the Balance Error Scoring System were showed that female participants in both groups had differences on SLSSF, TLSSF, TSSF ($p<0.05$), but there was no statistical difference among DLSHF, SLSHF, TLSHF, DLSSF, TSHF, BESST. It means there was no difference in static balance parameters of female participants in CTG and SG except for SLSSF, TLSSF, TSSF. (Table 4.8).

Table 4.9. Comparison of Balance Error Scoring System Variables between Male Participants and Female Participants in CTG.

	Male in CTG	**Female in CTG**	**p value**
DLSHF	0.0±0.0	0.20±0.42	p= 0.15, t: -1.50
SLSHF	1.50±0.70	1.90±0.56	p= 0.18, t: -1,39
TLSHF	0.70±0.67	0.90±0.56	p= 0.48, t: -0.71
DLSSF	0.70±0.67	0.90±0.73	p= 0.53, t: -0.63
SLSSF	2.3±0.82	2.9±0.99	p= 0.15, t: -1.47
TLSSF	1.50±0.97	2.0±0.94	p= 0.25, t: -1.16
TSHF	2.20±1.13	3.00±1.33	p= 0.16, t: -1.44
TSSF	4.5±2.17	5.8±2.57	p= 0.23, t: -1.22
BESST	6.70±2.94	8.80±3.61	p= 0.17, t: -1.42

Data expressed as mean ± standard deviation. SD: Standard deviation. n: number of participants. BESS= Balance Error Scoring System, DLSHF= Double Leg Stance on Hard Floor, SLSHF=Single Leg Stance on Hard Floor, TLSHF=Tenden Leg Stance on Hard Floor, DLSSF= Double Leg Stance on Soft Floor, SLSSF=Single Leg Stance on Soft Floor, TLSSF=Tendem Leg Stance on Soft Floor, TSHF= Total Scor on Hard Floor, TSSF=Total Scor on Soft Floor, BESST= Balance Error Scoring System Total. CTG: CrossFit Training Group.

The Kolmogorov-Smirnov test was used to test the numerical variables for normality, and it was determined that the distribution of test results was normal. Fort this reason, Independent-Samples T-Test was used for parametric values.

When Balance Error Scoring System measurement findings were compared, it was seen that there was no difference in static balance parameters of male and female athletes (Table 4.9).

5.DISCUSSION

Crossfit competitions are organized in many countries, including our country. The number of participants is increasing every day. However, studies on CrossFit are limited. Therefore, this study aims to examine the effects of CrossFit training on adults' static and dynamic balance.

The overall result of our study, when CTG and SG were compared, it was shown that CTG had a better dynamic balance than SG according to Y Balance Test results. CTG was found to be better in all three directions (A, PM, PL) in both the right and left lower extremities in the Y Balance Test ($p<0.05$), (Table 4.2). When we look at the Balance Error Scoring System (BESS), it was observed that CTG was better than SG in all parameters($p<0.05$) except double leg stance of hard floor and single-leg stance on the hard floor. Tandem leg stance on the hard floor, double leg stance on the soft floor, single-leg stance on the soft floor, tandem leg stance on the soft floor, the total score on the hard floor, the total score on the soft floor and BESS total parameters in BESS in CTG better than SG ($p<0.05$), (Table 4.3). The following results emerged that support the hypothesis of our study; CTG gave better results than SG in Y Balance Test and Balance Error Scoring System values.

When the Y Balance Test results of male participants in CTG and male participants in SG were examined, it was seen that male participants in CTG had a higher percentage of reaching in all 3 directions than male participants in SG, but there was no significant difference (Table 4.4). Comparing measurement findings of the Y-Balance Test between female participants in CTG and SG were showed that both groups had differences in PM-Right and Left ($p<0.05$), and in other parameters, it was seen that the female participants in CTG had better reaching percentages than female participants in SG. However, there was no significant difference (Table 4.5). According to the results of the Y Balance Test, when the dynamic balances of male and female athletes in CTG were compared, it was seen that there was no significant difference between them (Table 4.6).

According to the BESS evaluation results, when the results of male individuals in CTG and male individuals in SG were compared, TLSHF, DLSSF, SLSSF, TLSSF, TSHF, TSSF, BESST parameters were found to be better in male individuals in CTG (p<0.05), (Table 4.7). When we look at the BESS evaluation results to compare the results between female participants in CTG and female participants in SG, according to the results of SLSSF, TLSSF, TSHF, TSSF, the static balance of female participants in CTG is better (p<0.05), and in other parameters, there are fewer error rates than women in SG. However, it was seen that there was no significant difference (Table 4.8). When BESS measurement findings were compared between male and female athletes in CTG, it was seen that there was no difference in static balance parameters of male and female athletes (Table 4.9).

First of all, when CTG and SG were compared, it was shown that CTG had a better dynamic balance than SG according to Y Balance Test results. CTG was found to be better in all three directions (A, PM, PL) in both the right and left lower extremities in the Y Balance Test (p<0.05), (Table 4.2). When the Y Balance Test results of male participants in CTG and male participants in SG were examined, it was seen that male participants in CTG had a higher percentage of reaching in all 3 directions than male participants in SG, but there was no significant difference (Table 4.4). Comparing measurement findings of the Y-Balance Test between female participants in CTG and SG were showed that both groups had differences in PM-Right and Left (p<0.05), and in other parameters, it was seen that the female participants in CTG had better reaching percentages than female participants in SG. However, there was no significant difference (Table 4.5). When the other studies in the literature were analyzed, it was seen that a similar study was conducted with Student-Athletes. Engquist et al. reported that the purpose of this study was to analyze the comparison of performance between athletes and members of the general population. There were 270 participants in total. Of the participants, 151 were female and 119 were male. There were 167 student-athletes and 103 general university students. Composite and movement pattern scores were analyzed for the Functional Movement Screen. Composite and reaching direction scores were evaluated for the Y Balance Test. In this study, it was shown that the YBT composite scores of female student-athletes were higher than female general university students (p<0.05). There was no difference in YBT composite scores for men. The conclusion of this study is that student-athletes scored higher than general college students on the YBT among women. However, no differences in YBT reach directions or composite score were found in men (127).

Another study in the literature was carried out with the participation of dancers as follows. Harmon et al. reported that this study purpose to investigate balance and motor control in dancers and non-dancers with different foot positions. Eleven physically active female dancers and nine non-dancers were recruited for this study. Two different balance tests were used to evaluate physically active female dancers and non-dancers. They Evaluated in a single visit. The first of these tests is the Y balance test (YBT), and the second is the motor control test (MCT). Each test was performed in two different foot positions. One of the foot positions was the first ballet position, where the heels were touching and the feet were rotated 14 degrees from the outside. The second foot position was the sixth ballet position with the heels 10 cm apart and parallel to the front. While standing in the first ballet position of the participants in the dancer group, the Y Balance Test results were higher than the non-dancers ($p<0.05$). There was no significant difference in the YBT scores between the groups when standing in the sixth ballet position. The results of this study show that the dynamic balance of the dancers is better in the 1st foot position according to YBT than the non-dancers. (128).

According to our results, when the dynamic balances of male and female athletes in CTG were compared, it was seen that there was no significant difference between them (Table 4.6). When the other studies in the literature were analyzed, it was seen that another similar study was conducted with Crossfit athletes. Spaccarotella et al. purposed that to determine which gender had a better balance among CrossFit athletes. A total of 52 participants, 26 female and 26 male, aged between 18-70, were included in the study. Female participants were included in one group (n=26) and male participants in another group (n=26). Dynamic balance values of both groups were evaluated with Y Balance Test, and the results were compared. In conclusion, this study found that there was no difference in Y Balance Test composite scores between genders, but men had an increased likelihood of poor balance on their right side compared with women (9).

Another study in the literature was carried out with the participants of s of the female athletes who are in basketball, football, volleyball branches and female sedentary people. Gökdemir et al. purposed to explain the relationship between dynamic and static balance performances of the female athletes in basketball, football, volleyball branches, and female sedentary people. A total of 50 volunteers participated in the study. 34 of them were athletes, and 16 of them were sedentary individuals. Static balance was measured with the Flamingo Balance Test (FBT), and dynamic balance was measured with the Star Excursion Balance Test (SEBT), in which the Y Balance Test was modified. In this study to define the static and dynamic balance of women's basketball, football, volleyball players and sedentary, they found that the balance values of the sedentary were lower than the values of the athletes ($p<0.05$). They showed that basketball players got the best score in dynamic balance values, followed by volleyball and football players, respectively ($p<0.05$). As a result of the study, the reason why the balance performances of the athletes are better than the sedentary ones was accepted that regular training positively affected the psychomotor reactions of the athletes. The reason for the differences between the branches was explained as the development of balance differs in each branch (129).

According to our results; when we look at the Balance Error Scoring System (BESS) results, tandem leg stance on the hard floor, double leg stance on the soft floor, single-leg stance on the soft floor, tandem leg stance on the soft floor, the total score on hard floor, total score on the soft floor and BESS total parameters in BESS in CTG better than SG ($p<0.05$), (Table 4.3). When the results of male individuals in CTG and male individuals in SG were compared, TLSHF, DLSSF, SLSSF, TLSSF, TSHF, TSSF, BESST parameters were found to be better in male individuals in CTG ($p<0.05$), (Table 4.7). When we look at the BESS evaluation results to compare the results between female participants in CTG and female participants in SG, according to the results of SLSSF, TLSSF, TSHF, TSSF, the static balance of female participants in CTG is better ($p<0.05$), and in other parameters, there are fewer error rates than women in SG, but it was seen that there was no significant differences according to gender, (Table 4.8). When BESS measurement findings were compared between male and female athletes in CTG, it was seen that there was no difference in static balance parameters of male and female athletes (Table 4.9).

When the other studies in the literature were investigated, it was seen that a similar study was conducted with active and sedentary healthy young individuals. Petroman et al. purposed to assess the postural balance in active and sedentary healthy young individuals. Forty-four healthy young individuals with a mean age of 21.69±4.87 years were included in the study. Participants were divided into two groups as sedentary and physically active according to the short form of the International Questionnaire on Physical Activity (IPAQ). Physically active participants (group 1) were considered those who did five or more days of moderate-intensity physical activity for at least 30 minutes per session or vigorous physical activity for at least three days for at least 20 minutes per session. Subjects who had no physical activity during the week were assigned to the sedentary group (group 2). Balance Error Scoring System (BESS) was used to evaluate static balances. Group 1 included 22 active young individuals. The mean age of the subjects was 21.18±2.32 years and 59.09% were female. The sedentary group (group 2) consisted of 22 young individuals. The mean age of the participants was 22.22±6.61 years and 59.09% were women. The evaluation results of the sedentary group were significantly higher than the physically active group ($p<0.001$). Significant differences were found between the groups for tandem sides and bipeds on the soft surface ($p<0.01$). No significant gender differences were found for any of the evaluated test conditions. As a result, according to BESS results, it was found that the physically active group had better static balance than the sedentary group (130).

As far as we know, there are not many studies in the literature on the evaluation of the static balance of sedentary and athletic individuals using the balance error scoring system. Similar studies in the literature have been carried out using different balance tests, and it has been shown that the static balance of athletes is better than sedentary individuals (129,131). There were differences between the two groups in our study in all parameters except double leg stance on the hard floor and single-leg stance on the hard floor.

The limitations of our study;

-The most important limitation in our study was that there were restrictions during the measurements due to the Covid-19 outbreak. Gyms were closed as part of the Covid-19 measures. It was waited for the gyms to open to take measurements and for the athletes to start training again. Each athlete was evaluated individually 6 months after re-joining the training.

- Athletes in the CTG group were training with exercise loads of different intensity.

- There was a lack of information about daily activation of sedentary individuals who did not participate in CrossFit training.

Conclusion and Suggestion

- The main result of this study is that individuals who regularly participate in the CrossFit training program have better static and dynamic balances than sedentary individuals.
- The static and dynamic balances of the cases can be evaluated with Y Balance Test and Balance Error Scoring System.
- Balance is an important parameter to be able to perform activities of daily living. That's why this study is important.
- CrossFit training programs can be recommended in terms of improving the balance of people.
- The same study can be repeated for athletes in different sports branches engaged and sedentary individuals.
- The same study can be repeated for athletes in different sports branches engaged and CrossFit athletes.
- Similar studies can be carried out by increasing the number of participants.
- The research can also be carried out with only female participants or only male participants with a larger number of participants.

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7.APPENDIXES

7.1. Appendix 1 Ethical Committee Approval

T.C.
MARMARA ÜNİVERSİTESİ
Sağlık Bilimleri Enstitüsü
Etik Kurulu

PROJENİN ADI: Düzenli Olarak Crossfit Antrenmanı Yapan Bireylerde Statik ve Dinamik Denge Değerlendirilmesi
PROJE YÜRÜTÜCÜSÜ: Prof. Dr. Feryal SUBAŞI
PROJEDEKİ ARAŞTIRICILAR : İrem ÜNER
ONAY TARİHİ VE ONAY SAYISI: 13.07.2020-55

Sayın Prof. Dr. Feryal SUBAŞI

55 protokol nolu "Düzenli Olarak Crossfit Antrenmanı Yapan Bireylerde Statik ve Dinamik Denge Değerlendirilmesi" isimli projeniz Enstitümüz Etik Kurulu tarafından incelenmiş ve etik yönden uygunluğuna karar verilmiştir.

Prof. Dr. Feyza ARICIOĞLU
Komisyon Başkanı

Doç.Dr. İlkşan DEMİRBÜKEN — Prof. Dr. Dilşad SAVE

Prof.Dr. Hülya AŞÇI — Prof.Dr.Tuğba TUNALI AKBAY

Prof.Dr. Nefise BAHÇECİK — Doç.Dr. Ümit UĞURLU

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7.2. Appendix 2 Written Version of the Research Purpose and Plan

Siz katılımcılarımızı Fzt.İrem Üner tarafından yürütülen "Düzenli Olarak Crossfit Antrenmanı Yapan Bireylerde Statik ve Dinamik Denge Değerlendirilmesi" başlıklı araştırmaya davet ediyoruz. Bu araştırmaya katılıp katılmama kararını vermeden önce, araştırmanın neden ve nasıl yapılacağını bilmeniz gerekmektedir. Bu nedenle bu formun okunup anlaşılması büyük önem taşımaktadır. Eğer anlayamadığınız ve sizin için açık olmayan şeyler varsa bize sorunuz.

Sizler çalışmaya katılmama veya katıldıktan sonra herhangi bir anda çalışmadan çıkma hakkına sahipsiniz. Size verilen formlardaki soruları yanıtlarken kimsenin baskısı veya telkini altında olmayın. Bu formlardan elde edilecek bilgiler tamamen araştırma amacı ile kullanılacaktır.

Araştırmayla İlgili Bilgiler:

a. Araştırmanın Amacı: Bu araştırmanın amacı en az 6 aydır düzenli olarak Crossfit antrenmanı yapan bireyler ile en az 6 aydır herhangi bir egzersiz programına katılmamış sedanter bireylerin statik ve dinamik denge parametrelerini karşılaştırmak ve aradaki farkı değerlendirmektir.

b. Araştırmanın İçeriği:Katılımcıların statik ve dinamik denge parametreleri 2 farklı test ile değerlendirilir. 1. Grup; 20 kişi (en az 6 aydır Crossfit antrenmanlarına katılan) ve 2. Grup; 20 kişi (en az 6 aydır herhangi bir spor programına katılmamış olan) olacak şekilde iki grup oluşturulur. İlk grup(Crossfit yapan) en az 6 aydır haftada 3 gün olacak şekilde Crossfit antrenmanlarına katılmış olmalıdır. İkinci grup(kontrol grubu) en az 6 aydır herhangi bir spor dalıyla uğraşmamış olmalıdır. Her iki grup da aynı test ölçekleriyle değerlendirilir. İki grup arasındaki değişiklikler değerlendirilir ve karşılaştırılır.

c. Araştırmanın Nedeni: Yüksek Lisans Tez Çalışması

d. Araştırmanın Öngörülen Süresi: Değerlendirme süresi için 4 hafta

e. Araştırmaya Katılması Beklenen Katılımcı/Gönüllü Sayısı: 40

f. Araştırmanın Yapılacağı Yer: Maltepe Özel İlkem Özel Eğitim ve Rehabilitasyon Merkezi'nin Fizik Tedavi ve Rehabilitasyon Salonu

7.3. Appendix 3 Written Consent For Participants

Yukarıda yer alan ve araştırmadan önce katılımcıya/gönüllüye verilmesi gereken bilgileri okudum ve katılmam istenen çalışmanın kapsamını ve amacını, gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. Çalışma hakkında yazılı ve sözlü açıklama aşağıda adı belirtilen araştırmacı tarafından yapıldı, soru sorma ve tartışma imkanı buldum ve tatmin edici yanıtlar aldım. Bana, çalışmanın muhtemel riskleri ve faydaları sözlü olarak da anlatıldı. Bu çalışmayı istediğim zaman ve herhangi bir neden belirtmek zorunda kalmadan bırakabileceğimi ve bıraktığım takdirde herhangi bir olumsuzluk ile karşılaşmayacağımı anladım.

Bu koşullarda söz konusu araştırmaya kendi isteğimle, hiçbir baskı ve zorlama olmaksızın katılmayı ve yapılacak olan değerlendirme uygulamalarını kabul ediyorum.

<u>Katılımcının (kendi el yazısı ile)</u>

Adı-Soyadı:
İmzası:

<u>Araştırmacının</u>

Adı-Soyadı: Fzt.İrem ÜNER
Telefon numarası:
Mail:

<u>Danışmanın</u>

Adı-Soyadı: Prof. Dr. Feryal SUBAŞI
Telefon numarası:
Mail:

7.4. Appendix 4 Structured Questionnaire

TARİH: .../.../...

SAĞLIK BİLİMLERİ ENSTİTÜSÜ

FİZYOTERAPİ ve REHABİLİTASYON ANABİLİM DALI

ANKET

Demografik Özellikler

1.İSİM, SOYİSİM:

2.YAŞ:

3.CİNSİYET: ( ) Kadın ( ) Erkek

4.BOY (cm):

5.KİLO (kg):

6.DOMİNANT TARAF: Kol ( )sağ ( )sol

Bacak ( )sağ ( )sol

7.Her hangi bir kronik rahatsızlığınız var mı? ( ) Evet ( ) Hayır

Eğer evet ise, Hangisi?

( ) Romatizma ( ) Ortopedik Rahatsızlık ( )Nörolojik Rahatsızlık

( ) Diğer ....

8.Hiç ameliyat geçirdiniz mi? ( ) Evet ( ) Hayır

9.Hiç kaza geçirdiniz mi? ( ) Evet ( ) Hayır

10.Egzersiz yapıyor musunuz? ( ) Evet ( ) Hayır

Eğer evet ise hangi dalı, ne süredir ve ne sıklıkla? ....

7.5. Appendix 5 Evaluation Form

Adı Soyadı:
Doğum Tarihi:
Boy:
Kilo:
Bacak Boyu:
Dominant taraf:
Sporcuysa Ne kadar süredir Crossfit Antrenmanlarına katıldığı:

Y DENGE TESTİ

Y DENGE TESTİ	SAĞ	SOL
ANTERİOR		
POSTEROLATERAL		
POSTEROMEDİAL		

DENGE HATA SKORLAMA SİSTEMİ (BESS)

SKOR KARTI

DENGE HATA SKORLAMA SİSTEMİ(BESS)		
Skor Kartı: (#hatalar)	Sert Zemin	Yumuşak Zemin
Çift Bacak Duruş (ayaklar birleşik)		
Tek Bacak Duruş (dominant olmayan ayak üzerinde)		
Tendem Duruş (dominant olmayan ayak geride)		
Total Skor		
BESS TOTALİ		

BESS HATA TİPLERİ
İliak kanattan elleri çekmek Gözleri açmak Adım alma, sendeleme veya düşme Kalçayı 30°'den fazla abdüksyona alma Ön ayağı veya topuğu kaldırma 5 saniyeden fazla test pozisyonunun dışında kalma
BESS 6-20 saniyelik test süresi boyunca yapılan her hataya 1 hata puanı vermesi ile hesaplanır.