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Research article

Investigation of the effects of core training on some athletic performance parameters in male amateur football players

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Abstract: Core exercise is the region where the muscles have a significant effect on physical fitness and athletic performance level by providing the connection between the lower extremities and upper extremities. Although studies on core exercise have been conducted on different subjects for a long time, the number of studies in which the effects of core exercise on endurance, strength, sprint, anaerobic power, and balance performance are examined in the same study is limited. In this study, it was aimed to examine the effect of a twelve-week core exercise program on different performance outcomes for each motoric trait. In this context, 30 amateur football players were included in the study. The participants were randomly divided into two groups: the core exercise group (CEG) and the control group (CG). After the participants were determined, balance (flamingo and Y balance test), sprint (10 m and 30 m sprint test), strength (sit-up, push-up, back, and leg test), endurance (plank test), and anaerobic power analyses were taken and a 12-week core exercise program was applied to the CEG in addition to the football training program. CG was included in the normal football training program during this period. After 12 weeks, all performance measurements were repeated, and the differences between them were analyzed. According to the findings, we found a significant improvement in the participants' flamingo balance test, right foot post-medial Y balance test, right foot post-lateral, 10 meters sprint, 30 meters, leg strength, back strength, reactive strength index, push-ups, sit-ups, and plank tests ($p<0.05$). According to the findings, twelve-week core exercise program had a positive effect on endurance, strength, sprint, anaerobic power, and balance performance in football players.

Keywords: Football; Core training; Core Muscles; Performance; Motoric skills;

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1. Introduction

Football is the most popular sport in the world, watched and followed by millions, and is the dream of both boys and girls. It is a team sport in which factors such as strength, speed, flexibility, agility, balance, and muscle strength all affect the athlete's performance. Explosive forces such as jumping, ball interception, and acceleration are also common phenomena as performance indicators. Football players must possess these skills in order to achieve success [1]. There are many studies on the effects of different exercise types on these performance parameters [2–4]. The core exercise consists of muscle groups such as the pelvis, abdominal muscles, erector spinae, pelvic floor muscles, etc. and the feature provides upper and lower extremity connection for many forms of movement [4]. For a branch such as football, which requires different performance outputs, training the core muscles is important in increasing the level of technical, motoric, and athletic performance.

When the literature is examined, the number of studies examining the results of core exercise programs in football players is quite high. Some of these studies examined the effects on technical parameters [5], while others focused on the effects on performance parameters [6]. However, different studies argue that core exercise does not have a great effect compared to the literature. Nesser et al. analysed the relationship between strength parameters, bench press, squat, power clean 1 repetition maximum tests, vertical jump, sprint, and agility parameters, and core strength in football players. A moderate relationship was found between core strength obtained by trunk extension and flexion and strength and other performance tests. Even as a result of this study, it was concluded that every increase in core strength may not increase performance and technical parameters to the same extent [7]. Some studies have even compared different exercise modalities with the core exercise method. In the current study by Nambi et al., 40 m sprint, 4 x 5 sprint, submaximal shuttle running, countermovement jump, and squat jump performances were compared after 4 and 8 weeks and 3 months in a study in which isokinetic strength exercises and core exercise strength were applied. It was concluded that there were more significant increases in performance parameters in the group performing isokinetic strength exercises [8].

Some studies have concluded that static and dynamic core exercises have different effects on performance. In a study conducted by Parkhouse and Ball, static and dynamic core exercises were compared. Participants were tested such as plank, single leg stabilization, vertical jump, sprint, and overhead ball throwing. As a result, it was concluded that the participants did not improve in any performance test, but showed significant improvement in the core stabilization parameter [9]. When the results of these studies are evaluated, we think that core exercise programme has significant effects on different athletic performance outcomes.

However, we also see studies reporting the opposite in the literature. For this reason, it is thought that there is a need for studies examining the effects of core exercise programme on tests showing different motoric and performance characteristics. In this context, the aim of this study was to investigate the effects of a 12-week core exercise program on balance, strength, sprint, anaerobic power, and endurance performances in football players. As a result, the hypothesis of our research was determined as; '12-week core exercise program applied to football players increases balance, strength, anaerobic power, and endurance.'

2. Materials and Methods

2.1. Participants

This study is experimental in nature and each participant was included in our study voluntarily. This study was conducted in an amateur team in Ankara/Türkiye province. This research was conducted during the 2022-2023 football season. Thirty male amateur football players aged between 18-28 years participated in the study voluntarily. Participants who had an amateur football license for at least 1 year and regularly participated in weekly training programs were included in the study. Participants who had any orthopedic problems, who regularly used ergogenic aids to improve their performance, who had active infections, who had consulted a doctor with a cardio-pulmonary condition in the last six months, and who used antibiotics were not included in the study. Participants who did not regularly participate in the 12-week core exercise program and did not listen to or perceive the instructions of the principal investigator were excluded from the study and their families were informed. In the study, all trainings were performed on the football field. A 5-minute warm-up was performed before the exercise and a 5-minute cool down was performed after the exercise. Player groups were divided into two as experimental (CEG)

and control groups (CG) using the random sampling method. Both groups participating in the study continued their football training, but in addition to this training, an extra core training program was applied to the CEG, 3 days a week for 12 weeks (Table 1). Preliminary tests were performed on all football players at the beginning of the study and the results were recorded. After the 12-week period, final tests were performed and recorded on the group of players.

Table 1. Core Training Program

EXERCISES	**1-4 WEEKS**	**5-8 WEEKS**	**9-10 WEEKS**	**11-12 WEEKS**
	TIME/SET	**TIME /SET**	**TIME /SET**	**TIME /SET**
1-Plank	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition
2-Single Leg Plank Raise	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition
3-Burpees	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition
4-Double Crunch	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition
5-Ankle Wiggles	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition
6-Push up Superman / Alternating Arms	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition
7-Belly Blast	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition
8-Air Bike Crunches	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition
9- Mountain Climber	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition
10-. Lying Twist Trunk	25 sec x 2	30 sec x 3 repetition	35 sec x 3 repetition	40 sec x 3 repetition

The ethics committee report required for our research was approved by the decision of the Ethics Committee of Selçuk University, Faculty of Sports Sciences, dated 28.01.2021 and numbered 10. The football player group participating in the study was informed about the measurements to be made for the research and the measurements were made by the researcher. All procedures to be performed in this study were explained to the participants in detail. The families of the participants under 18 years of age were also informed and their voluntary consent was obtained.

Research Design. The CEG continued their routine football training program and also performed core exercises. After the demographic characteristics (age, height, weight, and BMI) of the participants were obtained, the leg lift test, back strength, and leg strength were measured to determine the strength performance of the participants. The balance performance of the participants was measured by the Y balance test and the flamingo balance test. Sprint performance was measured by 10m and 30m sprint tests, and endurance performance by plank test, push-ups, and sit-up tests.

2.2. Data Collections Tools.

Leg Raise Test: The players extended their feet 10 cm above the ground and parallel to the ground, with their backs in contact with the mat spread on the ground. In this posture position, they placed their hands in the empty area between the back and hip area. In this way, the back muscles are supported and the amount of load on the hip and leg area is increased. The test was terminated when the foot touched the ground, or the stance position was disrupted. This measurement was determined with a stopwatch in seconds [9].

Back and Leg Strength Test: The participants' back and leg strength values were measured with a back and leg dynamometer (Takei TKK5402 brand). After the participants placed their feet on the dynamometer in a position with their knees bent for leg strength and their knees stretched for back strength measurement, they pulled the dynamometer bar vertically upwards, with the arms stretched, the back straight and the body slightly leaning forward. Players were given the opportunity to perform the movement twice for these measurements and the best result was determined with an accuracy of 0.1 kg. The athletes were given a 5-minute rest period between measurements [10].

Push-up and Sit-up Test: A 60-second push-up test was used to evaluate the athletes' whole-body muscles and upper extremity endurance. The participants took a push-up position on the mat, put their hands forward, placed their heels in a pivotal position, kept their backs straight, and kept their forearms and elbows bilaterally at shoulder width, while placing their shoulders, back, hips, and legs parallel to the floor. When they were ready, they started doing push-ups. They completed one push-up by bringing their chests closer to the mat and straightening their elbows again. The number of push-ups they performed in the same movement with maximum strength and in the correct posture within 1 minute without rest was recorded and the result was determined as a numerical value.

It is a test protocol used to measure the core strength of the abdominal area of athletes. During the measurement, the athlete positioned himself on a mat with his legs bent at a 90-degree angle, his knees bent and his hands behind his head, and the number of sit-ups he performed without any errors within 1 minute was recorded [11,12].

Plank Test: Athletes were asked to lie face down and position their forearms and elbows bilaterally at shoulder width and on their toes. By standing in this way, the pelvis was lifted and the neck, shoulders, back, hips, and legs were asked to form a straight line parallel to the ground and to maintain this posture. Once the time started, the time until the athletes got tired or broke their stance was recorded in seconds [13].

10m and 30m Sprint Test: The test was carried out with a photocell with a sensitivity level of 0.01 s (Smart Speed, Australia). The distances to be measured in the training field, which has an artificial grass ground, were determined beforehand and photocells were placed at suitable points for measurement. Athletes were asked to start running standing 1 m behind the starting point. The football players were made to run one by one for measurement. Each athlete was given 2 attempts for the distance to be measured and the best time was recorded. The athletes were given a 5-minute rest period between two measurements [14].

Reactive Strength Index (RSI): Reactive strength index measurement was performed with "My Jump 2", a phone application whose validity and reliability were previously accepted. Each player was told to perform a drop jump (DJ) from the 30 cm high crate with his hands on his hips. When they fell to the ground, they were asked to touch the ground with one foot and jump upwards as quickly as possible. Measurements were taken at 240 Hz via iPhone 11 (Apple Inc., USA) brand phone. It was recorded

thanks to high-speed video shooting. Measurement results were calculated and recorded with the "My Jump 2" application [15].

Y Balance Test: *The* dynamic balance of the participants is measured with the Y balance test. Participants were asked to place their right and left feet respectively on the middle part of the test apparatus and try to maintain their balance by reaching in the anterior, posteromedial and posterolateral directions with their free foot. Athletes reached as far as their fingertips could reach. Each point that the fingertip could reach was moved 3 times and the most successful measurement was recorded in cm [16].

Flamingo Balance Test: The balance performance of the body is measured by having the players stand on one leg. With this test, static balance is evaluated. The participant tried to balance with his/her dominant foot on a wooden mechanism (50 cm long, 5 cm high and 3 cm wide). The participant was allowed to have a helper hold his arm to get into the correct position. The test started as soon as the assistant released his arm and the participant was asked to maintain his balance for 1 minute. Timer was stopped each time the participant lost balance. The participant was considered unbalanced if he let go of his foot, which he was holding with one hand, or if any part of his body came into contact with the ground. Each time the timer was stopped, the starting position was taken back and the time was started again, and every time he lost his balance was recorded [17]

Statistical Analysis: In the study, the core strength training program was applied for 12 weeks. The variables of the study and control groups are stated as arithmetic mean, standard deviation, minimum, and maximum values in descriptive statistics. SPSS 26.0 package program was used to analyze the data obtained. Descriptive variables regarding age, weight, and height of male amateur football players participating in the research are presented. Body fat percentage, body mass index, flamingo balance test, Y balance test, 10- and 30-meter speed test, sit-up, push-up, leg lift, plank, back strength and leg strength test, reactive force index of male amateur football players in the control and study groups. According to this information, normality analysis was performed with Shapiro Wilk test and it was determined that the data showed normal distribution. The Levene test was used for homogeneity of the variances. Repeated Measures Anova test was used to determine the difference between the pre-test and post-test measurements of the data. Dependent Groups (Paired Samples) T-test was used for intra-group comparison of dependent groups. The statistical significance level was adopted as $p<0.05$.

3. Results

Table 2 shows the demographic characteristics of the participants. In the study, the average age of male amateur football players in the control group was 22.3±3.94 years, while in the CEG it was 24.00±3.2 years. The average height was 179.4±5.47 cm in the control group and 179.00±4.83 cm in the CEG. The average body weight was 72.99±3.87 kg in the control group and 73.05±4.41 kg in the CEG.

Table 2. Experimental and Control group descriptive information

	Experimental Group					Control Group				
	n	Min	Max	Mean.	Sd	n	Min	Max	Mean.	Sd
Age	15	18	28	24.00	3.2	15	18	28	22.53	3.94
Weight	15	65.70	79.70	73.05	4.41	15	65.40	78.00	72.99	3.87
Height	15	171	185.00	179.00	4.83	15	170.00	186.00	179.40	5.47

In Figure 1, the balance performances of the participants were analyzed. According to this, the flamingo balance test differed significantly after the core exercise program (F=4.638, η^2p=0.142, p=0.049). When Y balance performance was analyzed, except for the right posterior medial (F=4.443, η^2p=0137, p=0.044), there was no significant improvement in the other directions (p>0.05).

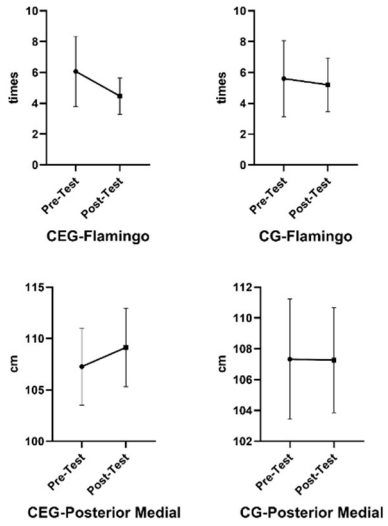

Figure 1. Comparison of the results of balance performances of the participants

In Figure 2, the endurance performances of the participants were analyzed. Accordingly, the results of the push-up test, sit-up test, and plank test were significantly different after the core exercise program (F=7.692, η^2p=0.216, p=0.010, F=17.818, η^2p=0.389, p=0.017, F=12.339, η^2p=0.306, p=0.002, respectively).

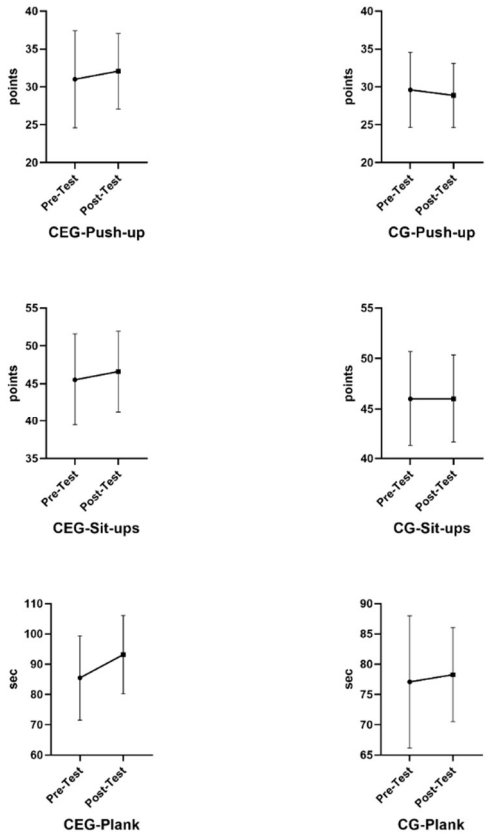

Figure 2. Comparison of the results of endurance performances of the participants

The sprint performances of the participants were analyzed in Figure 3. According to this, 10m and 30m sprint performances differed significantly after the core exercise program (F=8.191, η^2p=0.226, p=0.008, F=4.380, η^2p=0.135, p=0.046, respectively).

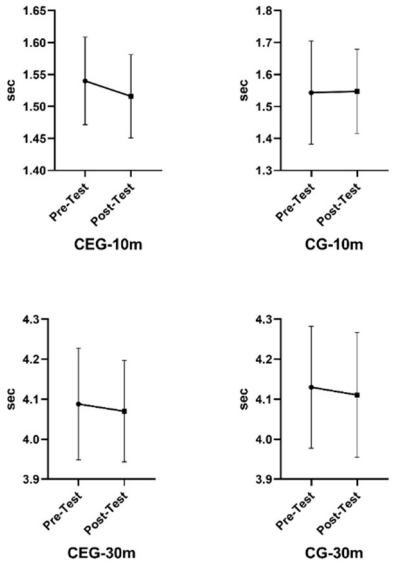

Figure 3. Comparison of the results of sprint performances of the participants

In Figure 4, the RSI results from the strength and anaerobic power performances of the participants were analyzed. Leg strength and back strength of the participants changed significantly after the core exercise program (F=4.274, η^2p=0.132, p=0.048, F=6.136, η^2p=0.180, p=0.002, respectively). RSI results of the participants also showed a significant difference (F=6.417, η^2p=0.186, p=0.017).

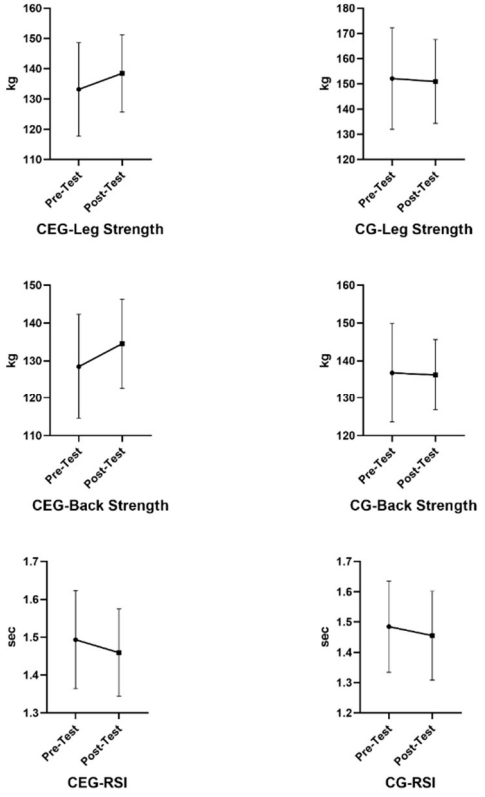

Figure 4. Comparison of the results of strength performances of the participants

4. Discussion

This study investigated the effects of twelve weeks of core exercise on balance, sprint endurance, strength, and anaerobic strength parameters. At the same time, different tests were applied for each performance indicator. According to the results obtained, 12 weeks of core exercise positively affected the balance, endurance, strength, anaerobic power, and sprint performance of male amateur football players. Therefore, our hypothesis '12-week core exercise program applied to football players increases balance, strength, anaerobic power, and endurance.' was confirmed.

The role of core muscle structure and various training methods were investigated to understand how they affect performance and health in sports. Many studies show that core exercises improve stability and neuromuscular control between the spine and pelvis and increase endurance, strength, and power in the trunk muscles [18]. Additionally, they can facilitate force transfer between the upper and lower extremities, increase static and dynamic balance, and improve the execution of certain sports skills. As a result, an appropriate level of core stability and strength can improve sports performance and physical fitness, prevent various musculoskeletal injuries, and optimize training adaptations in athletes [19].

Our research gives important results in terms of using different tests for the same performance parameter. For example, the flamingo balance test and Y balance tests were applied for balance performance in our study. Flamingo balance test results increased significantly after core exercise, while in the Y balance test, only posterior medial and posterior lateral balance performance of the right foot improved significantly. There was no improvement in other directions. This may be due to the difference between dominant and non-dominant foot strength and balance performances in football players in previous studies [20]. In a study in which the quadriceps muscle morphology of football players was investigated, it was found that quadriceps muscle hypertrophy was higher in football players compared to taekwondo and athletics athletes [21]. This result suggested that the muscle strength and size were high in football players, and since the dominant foot was actively used during training and competition, the results of the Y balance test affected only the posterior data of the right leg. In general, when the effects of core training on balance performance are examined, it can be said that it gives positive results [22–25]. However, we think that the results of balance analyses such as the Y balance test, in which the balance of muscles in different directions is measured, should be examined in detail.

Another important finding of the study was the results on sprint performance. Both 10m and 30m sprint performances improved significantly after core training. However, 10m sprint performance was higher in terms of effect size than 30m sprint performance. This suggests that more emphasis should be placed on strength endurance training along with core muscle strength during core training. Previous studies have found that core strength exercises have positive effects on sprint performance and repetitive sprint performance [26,27]. In this context, although the findings obtained in our study are similar to the literature, it was concluded that aerobic endurance is also important as the distance sprinted increases in terms of effect size. In an important recent study that we think confirms this result, it was concluded that the level of core strength strengthens especially sprint output. This confirms the positive effect of core training on short-distance explosive velocity [28].

In our study, there was a significant improvement in strength parameters. According to this, there is a significant increase in the back and leg strength of the participants after the core exercise program. At the same time, RSI, which is an indicator of the anaerobic performance of the participants, was significantly improved. After a 3D analysis of pelvis and core muscle forces during walking by Carpes et al., it was found

that strengthening exercises applied to the lumbar region reduced pain and significantly improved gait biomechanics [29]. The increase in muscular endurance and strength after core analysis is the main reason for the difference in strength-related parameters. It is clear that core training contributes to the development of lower and upper extremity muscles.

This can be explained by the fact that there is a significant difference in movements that use both the core muscles and the lower and upper extremity muscles, such as sit-ups, push-ups, and planks. This is because a significant difference was found in this study with respect of both back and leg muscles in the pre-test and post-test comparison of the study group. The increase in back and leg strength may be a factor in the difference in sit-ups, push-ups, and planks. Exercises performed on the core area are also expected to increase muscle endurance in this area. We think that the endurance exercises we applied in our training plan affected this [30]. In a recent systematic review study, trunk flexion strength, trunk extension strength, right and left lateral flexor strength, and endurance were significantly increased in exercises performed on the core [31].

This research has some limitations. One of the most important limitations of this research is that only the effects on a specific sports branch are analyzed. Another important limitation is that only male amateur football players were included in the study. The possible effects of core exercise program applied on different sports branches on the technical skills required by the branch can be examined. It is also thought that the effects on professional athletes are also important. Due to the different physiological and anatomical conditions in women, there is also a need for studies examining the effects of core exercise on women.

5. Conclusions

The results of this study revealed the possible effects of chronic core exercise programs on physical performance and some motoric characteristics of amateur football players. Accordingly, considering its effects on performance parameters such as balance, endurance, sprint, strength, and anaerobic power, it may be a method that should be applied in addition to football training programs. In sports branches that require dynamic and versatile skills such as football, active training of the core region offers important outcomes in both preventing injuries and increasing performance. In addition, this research can be conducted on professional athletes of different age groups and genders to examine the possible effects. In addition, long-term studies examining the effects of core exercise on the risk of injury can be conducted. Research can also be conducted in which the effects of core exercise in different sports branches and sports branch-specific performance parameters are comparatively examined. In addition, studies can be conducted to examine the effects of core exercise programs combined with exercises such as static, dynamic, or plyometric exercises. Coaches can include core exercises in their plans when planning macro and micro training plans. In conclusion, this study clearly demonstrates the effects of core exercises on improving the physical performance of football players and provides an important guide for coaches, athletes and researchers. Core exercises are a powerful tool for football players to both increase their physical endurance and optimise their performance.

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