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ORIGINAL RESEARCH

The effect of core exercises applied to 9-12 year old football players on biomotor characteristics

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Abstract. The aim of this research is to examine the effects of core exercises applied to 9-12 year old football players on biomotor parameters such as strength, speed, flexibility, endurance and agility. Thirty volunteer male athletes receiving football training at the Bitlis Güroymak Youth Services and Sports District Directorate participated in the study. The study consisted of two groups (football+control group n=15 and football+core training group n=15). Both study groups continued their football training, but the study group also completed a core exercise program three days a week for eight weeks. To measure the participants' biomotor characteristics, sit-reach-reach, vertical jump, Illinois agility, 20 m sprint, 30 sec sit-ups, 30 sec push-ups, right and left hand grip strength, 20 m shuttle run tests were applied as pre-test and post-test. SPSS program was used to statistically analyze the data obtained as a result of the research. The Shapiro-Wilk test was used to test for normality, and the Levene test was used to test for homogeneity. Skewness and kurtosis values were checked for data sets that did not show a normal distribution, and data sets with a value within ±2 were considered to have a normal distribution. Two-way analysis of variance (2x2) was applied to analyze differences between treatments for repeated measurements. Post hoc analysis used the Tukey test. Statistical results were evaluated at $p<0.05$ significance levels. Based on the pre- and post-test results of the football+control and football + core groups, statistically significant differences were found between the groups in the vertical jump, 30-second sit-up test, 30-second push-up test, 20-meter sprint test, and Illinois agility test. In conclusion, it was determined that core exercises applied to soccer players positively affect vertical jump, 30-second sit-ups, 30-second push-ups, 20-meter sprint, and Illinois agility performance.

Introduction

For athletes aged 14 and under, core training exercises are a very effective and good training method for increasing muscle strength and capacity (Aşçı, 2011). Football, played by millions of people at both amateur and professional levels, has also become a major industry. Football is a sport that is recognized and played in almost every country in the world (Orta, 2020). As it is the largest organization in the world, it has a great interaction between sports branches in social, cultural and economic terms. Football is a sport with its own rules that many people start playing with pleasure from an early age and that is enjoyed by many people when they watch it, and in which players express both their psychological and physical characteristics in full harmony (Sever & Zorba, 2017). Football training aims to improve players' speed, agility, endurance, ball control and strategic thinking skills (Köklü et al., 2009). From a sporting perspective, it is commonly assumed that athletes with superior physical attributes tend to demonstrate better performance outcomes compared to those with weaker physical structures (Ozaltaş & Özbek, 2021). To improve performance, a strong core is essential. Core exercise programs are used to develop this strength. Core exercise programs are exercises that aim to strengthen the muscle groups that make up the center of the body. Muscle groups include the abdominals, back, pelvic floor, and side muscles. Core exercises can help improve posture, increase endurance, reduce back pain, and provide overall body stability (Hibbs et al., 2008). Especially recently, core exercises have begun to be widely used to develop these muscle groups. It is explained that strengthening the core regions has many effects on improving sports performance (Gönener et al., 2017; İri et all., 2021).

Core exercises are important for football players to strengthen their core muscles, increase endurance and optimize their performance on the field. Core muscles include general and local muscles that help stabilize and control the trunk (Hibbs et al., 2008; Willardson, 2007). The core is anatomically characterized as a box formed by various muscle

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groups: the rectus abdominis in the front, the internal and external obliques laterally, the erector spinae, lumbar multifidus, and quadratus lumborum in the back, the diaphragm and pelvic floor superiorly, and the iliopsoas at the inferior boundary (Akuthota et al., 2004; Shinkle et al., 2012). From a functional standpoint, the core represents the central region of the body, serving as the primary site where kinetic chains transmit forces to the extremities (Shinkle et al., 2012). Nevertheless, fitness and health professionals identify the transversus abdominis, lumbar multifidus, and quadratus lumborum as key core muscles (Martuscello et al., 2013). Core muscles include the abdominal, back, pelvic, and lateral muscles. These muscle groups enable football players to move quickly, maintain their balance, handle the ball, and shoot (Afyon, 2014; Aslan et al., 2018; Dikici, 2018; Sun et al., 2016). Core exercises are a key component of overall health and performance. Suitable for individuals of all ages and abilities, these exercises play a crucial role in improving overall health and fitness. Regular core exercises contribute to improved balance, posture, and overall athletic ability, and can improve quality of life. Therefore, core exercises should be considered an important part of individual training programs (Willardson, 2018). The aim of this research is to examine the effects of core exercises applied to 9-12 year old football players on biomotor parameters such as strength, speed, flexibility, endurance and agility.

Method

This study employed an experimental design, and all participants took part on a voluntary basis. A total of 30 healthy male volunteers participated in the study. The football+control group (n = 15) consisted of individuals receiving football training at the Bitlis Güroymak Youth Services and Sports District Directorate, while the experimental group (n = 15) received both football and core training.To determine the sample group, the confidence interval of the Power Analysis test was determined as = .95, alpha value = .05 and beta value = .80. Power analysis determined that 15 participants per group was sufficient. Volunteers were randomly assigned to the study groups. Permission was obtained from the Güroymak Youth Services and Sports District Directorate so that the research could be conducted at the institution and athletes could be included in the research. Volunteers participating in the study were interviewed face-to-face. They were informed about the content and methodology of the study. Individuals who met the inclusion criteria and volunteered for this research were identified, an informed consent form was signed, and parental permission was obtained. Inclusion criteria for the study were: not having sustained an upper or lower extremity injury in the past 90 days, not having serious hearing or vision problems, respiratory or cardiac diseases, not using physiological ergogenic aids or medications, and demonstrating regular and continuous participation throughout the study.

Both the football+control group (n = 15) and the football+core training group (n = 15) continued their regular football training throughout the study. Additionally, the experimental group completed a supplementary core exercise program three times per week for a duration of eight weeks.

Data Collection

Body weight and height measurement: Subjects were prepared for the measurement with bare feet and clothing that would not affect their weight. Measurements were taken using a scale (Techfit TF-1052 Square Digital Glass Scale) with a precision of 0.01 kilograms, and results were recorded in kilograms. Participants' heights were measured with a stadiometer accurate to ±1 mm, while they wore sports clothing, remained barefoot, and held their heads in the Frankfort plane position. After a deep inspiration, the vertical distance from the vertex of the head to the feet was recorded in centimeters (Hoffman, 1996; Ehrman et al., 2003).

Vertical jump test: Participants stood in front of a wall whose height was specified in centimeters, feet shoulder-width apart, and their torso parallel to the wall. The distance they could reach was measured. Each subject was then given three attempts in the same position, and the best of these attempts was included in the evaluation. The difference between the maximum distance the subjects could reach while standing and the maximum distance they could reach while jumping was determined in meters (Uzlaşır & Erden, 2016; Souza et al., 2020).

30-second sit-up test: Participants took the starting position lying on their backs, knees bent, feet on the floor, and hands touching the shoulders. Once they were ready, they began doing sit-ups at maximum performance for 30 seconds. Support was provided to keep participants' feet stable during the test. The movement was completed at the point where the shoulders approached the kneecaps, then returned to the starting position and repeated. Each participant was given two trials and the highest number of repetitions was recorded (Bozbay et al., 2023; Musa, 2020; Safrit et al., 1992, Diener et al., 1995; Vispute et al., 2011).

Prior to the 30-second push-up test, the procedure was thoroughly explained to the participants, and the

correct technique was demonstrated. Errors that could lead to invalidation were explained to the participants in detail. Participants started in a prone position on the mat, with hands at shoulder height and legs straight, parallel, and slightly separated. The participant maintained a straight body posture until the arms were fully extended, then lowered the body in a controlled manner until the elbows reached a 90° angle and the upper arms were parallel to the floor.Participants performed as many repetitions as possible during the testing period. Errors were not included in the analysis, and the number of correct push-ups was recorded (Wood & Baumgartner, 2004; Uçan et al., 2018; Tamer, 2000; Chen et al., 2018).

The Illinois agility test is designed to assess an athlete's speed and agility development. The course measures 10 meters in length and 5 meters in width, defined as the distance between the start and finish points.The course allows for the use of five lanes, with four cones positioned to indicate the start, finish, and the two turning points. The cones placed in the center of the course are spaced 3.3 meters apart.Participants' completion times for the course were measured using electronic photocell gates placed at the start and finish points. Each participant was given two attempts and the best time was taken into consideration (Mackenzie, 2005; Miller et al., 2006; Hazır, 2010).

20-meter sprint test: Timing was measured using an electronic photocell positioned at both the start and finish lines.The test concluded with subjects preparing to start the time by passing through the photocell covers at the starting point and stopping the time by running through the covers at the finish line. To ensure that the subjects' running performance was not adversely affected and to provide a standardized measurement, a cone was placed before the starting photocell, ensuring that all subjects started from the same line. Participants were given two attempts, and their best times were evaluated (Cinthuja et al., 2015).

Core exercise program applied to participants: Between 1 and 4 weeks, plank, side plank, hipextension, two-leg floor bridge, side ski jumps and floor cobra movements were performed for 25 seconds and 2 repetitions. Between 5 and 8 weeks, plank, side plank, hipextension, two-leg floor bridge, side ski jumps and floor cobra movements were performed for 25 seconds and 3 repetitions. To assess the athletes' biomotor characteristics, pre- and post-tests were conducted, including the vertical jump, 30-second sit-up, 30-second push-up, 20-meter sprint, and Illinois agility test. All results were recorded as pre-test and post-test values.The core exercises prepared for the research group were determined through literature research and the core training program was planned and implemented by the researcher (Boyacı at all, 2018).

Data Analysis

SPSS was used to analyze the data collected in this study, and the results are reported as arithmetic means and standard deviations. Normality was assessed using the Shapiro-Wilk test, while homogeneity of variance was evaluated with the Levene test. For datasets that did not meet normality, skewness and kurtosis values were examined, and datasets with values within ±2 were considered normally distributed (George & Mallery, 2010). A two-way repeated measures analysis of variance (2×2) was conducted to examine differences between conditions. When the assumption of sphericity was violated, the Greenhouse-Geisser correction was applied. Post hoc comparisons were conducted using the Tukey test. Effect sizes for the two-way ANOVA were reported as partial eta squared (η^2p) and interpreted according to the following criteria: minimal effect ($\eta^2p \leq 0.02$), medium effect ($0.02 < \eta^2p \leq 0.09$), and large effect ($\eta^2p > 0.09$) (Lakens, 2013). Statistical significance was set at $p<0.05$.

Findings

Table 1 shows that participants who only attended the football school had a body weight of 35.31±6.41 kg and a height of 137±0.06 cm; while those who attended both the football school and core exercises had a body weight of 31.03±5.50 kg and a height of 135±0.10 cm.

Table 2 displays the statistical analysis of vertical jump performance for both the football and football+core groups between pre- and post-test measurements. The repeated measures two-way ANOVA revealed a significant difference between groups ($F = 11.803$, $p = 0.004$, $\eta^2p = 0.457$); however, no significant differences were observed across time points ($F = 0.806$, $p = 0.385$, $\eta^2p = 0.054$) or in the group × time interaction ($F = 0.153$, $p = 0.701$, $\eta^2p = 0.011$).

Table 3 presents the statistical analysis of 30-second sit-up performance for the football and football+core groups between pre- and post-test measurements. Repeated measures two-way ANOVA revealed significant differences between groups ($F = 6.199$, $p = 0.026$, $\eta^2p = 0.307$), whereas no significant differences were observed across time points ($F = 0.016$, $p = 0.899$, $\eta^2p = 0.001$) or in the group × time interaction ($F = 1.527$, $p = 0.237$, $\eta^2p = 0.098$).

Table 4 displays the statistical analysis of 30-second push-up performance for the football and football+core groups between pre- and post-tests. Repeated measures two-way ANOVA revealed significant differences between groups ($F = 10.137$, $p = 0.007$, $\eta^2p = 0.420$), whereas no significant differences were observed across time points ($F = 0.120$, $p = 0.735$, $\eta^2p = 0.008$) or in the group × time interaction ($F = 1.627$, $p = 0.223$, $\eta^2p = 0.104$).

Table 1. Descriptive statistics

		$\bar{x}$	s.s.
Football	Height (cm)	137	0.06
	Weight (kg)	35.21	6.41
Football + Core	Height (cm)	135	0.10
	Weight (kg)	31.03	5.50

Table 2. Statistical analysis of vertical jump application across groups and time periods

			95% confidence interval		Group			Time			Group*Time		
		$\bar{x}$.±s.s	**Lower**	**Upper**	**F**	**p**	**η^2p**	**F**	**p**	**η^2p**	**F**	**p**	**η^2p**
Football	Pretest	16.1±2.70	14.6	17.6	11.80	**0.00**	0.45	0.81	0.38	0.05	0.15	0.70	0.01
	Post test	16.2±2.70	14.7	17.6									
Football + Core	Pretest	17.9±2.36	16.6	19.2									
	Post test	18.7±2.73	17.2	20.2									

Table 3. Statistical analysis of the 30-second sit-up test application across groups and time periods

			95% confidence interval		Group			Time			Group*Time		
		$\bar{x}$.±s.s	**Lower**	**Upper**	**F**	**p**	**η^2p**	**F**	**p**	**η^2p**	**F**	**p**	**η^2p**
Football	Pretest	11.3±2.55	9.86	12.7	6.20	**0.03**	0.30	0.02	0.89	0.001	1.52	0.23	0.09
	Post test	10.3±2.23	9.10	11.6									
Football + Core	Pretest	12.3±3.81	10.16	14.4									
	Post test	13.3±3.06	11.64	15									

Table 4. Statistical analysis of the 30-second push-up test application across groups and time periods

			95% confidence interval		Group			Time			Group*Time		
		$\bar{x}$.±s.s	**Lower**	**Upper**	**F**	**p**	**η^2p**	**F**	**p**	**η^2p**	**F**	**p**	**η^2p**
Football	Pretest	10.2±2.18	8.99	11.4	10.13	**0.01**	0.42	0.12	0.73	0.10	1.62	0.22	0.10
	Post test	9.6±1.35	8.85	10.3									
Football + Core	Pretest	11.4±2.69	9.91	12.9									
	Post test	12.3±2.40	10.94	13.6									

Table 5. Statistical analysis of the 20-meter sprint test application between groups and times

			95% confidence interval		Group			Time			Group*Time		
		x̄.±s.s	Lower	Upper	F	p	η²p	F	p	η²p	F	p	η²p
Football	Pretest	6.23±1.34	5.49	6.98	12.79	**0.00**	0.47	0.04	0.83	0.00	0.36	0.56	0.02
	Post test	6.47±1.23	5.79	7.15									
Football + Core	Pretest	5.24±1.11	4.62	5.86									
	Post test	5.11±1.10	4.50	5.72									

Table 6. Statistical analysis of Illinois agility test administration across groups and time points

		95% confidence interval		Group			Time			Group*Time		
	x̄.±s.s	Lower	Upper	F	p	η²p	F	p	η²p	F	p	η²p
Football	Pretest	25.8±5.29	22.9	28.7	5.18	**0.04**	0.27	0.00	0.95	0.00	0.41	0.53	0.03
	Post test	26.6±4.51	24.1	29.1									
Football + Core	Pretest	23.9±4.80	21.3	26.6									
	Post test	23±3.82	20.9	25.2									

Table 5 presents the statistical analysis of 20-meter sprint performance for the football and football+core groups between pre- and post-tests. Repeated measures two-way ANOVA revealed significant differences between groups ($F = 12.795$, $p = 0.003$, $\eta^2p = 0.478$), while no significant differences were observed across time points ($F = 0.046$, $p = 0.833$, $\eta^2p = 0.003$) or in the group × time interaction ($F = 0.361$, $p = 0.557$, $\eta^2p = 0.025$).

Table 6 presents the statistical analysis of Illinois agility test performance for the football and football+core groups between pre- and post-tests. Repeated measures two-way ANOVA indicated significant differences between groups ($F = 5.181$, $p = 0.039$, $\eta^2p = 0.270$), whereas no significant differences were observed across time points ($F = 0.003$, $p = 0.959$, $\eta^2p = 0.000$) or in the group × time interaction ($F = 0.412$, $p = 0.531$, $\eta^2p = 0.029$).

Discussion and Conclusion

It is known that core exercises have an impact on the prevention of injuries due to increased muscle strength, the development of coordination in various muscle systems, and the development of motor skills such as quickness, speed, balance, and long jump, which are important for the football branch (Prieske et al., 2015).

Several studies in the literature have investigated the effects of core training on vertical jump performance. In a study examining the impact of core training on selected motor skills in football players, Boyacı (2016) supplemented the experimental group's football training with core exercises twice weekly for 12 weeks. Post-test results indicated statistically significant improvements in all measured parameters for the experimental group.

İri et al. (2021) investigated the effects of core exercises on selected motor characteristics in football players. The study assessed participants' speed, vertical jump, and agility performance. Comparison of pre- and post-test results in the experimental group revealed statistically significant improvements in the 20-meter sprint, vertical jump, and agility measures.

The study by Pancar (2023), which investigated the effects of core training on the physical performance of amateur football players, aligns with the findings of the present research. Similarly, Boyacı (2016) and İri et al. (2021) reported that core exercises produced significant positive effects on vertical jump performance in football players.

Core muscle exercise appears to be important for vertical jump performance. It is thought that the main way to improve vertical jump performance enough to make a significant difference is to increase lower extremity strength.

Arı and Çolakoğlu (2021) investigated the impact of core exercises on tennis performance in tennis players. Their findings indicated that the experimental group demonstrated statistically significant improvements in post-intervention

measurements of standing long jump, handgrip strength, sit-and-reach flexibility, and sit-up performance compared to pre-intervention values ($p < 0.01$).

Sekendiz et al. (2010) examined the effects of core exercises on multiple biomotor characteristics in 21 sedentary women with a mean age of 34. The findings revealed statistically significant improvements in endurance (sit-up test), flexibility, and balance among participants who performed core-strengthening exercises.

Boyacı and Afyon (2017), in their study examining the effects of core exercise on physical performance in athletes, found positive statistically significant differences in push-up performance at the end of 12 weeks of core exercises.

A review of the literature reveals numerous studies examining the relationship between core exercises and strength performance. It is believed that differences in the results of studies on the effects of core exercises on strength performance may be due to internal and external factors such as the participants' age, gender, and length of time in the sport, as well as the duration and frequency of the exercises and the participants' training levels.

A review of the literature generally indicates that core exercises positively influence sprint performance (Gücük & Aydoğmuş, 2023; Özcan, 2018; Weston et al., 2015; Sannicandro et al., 2020; Kabadayı et al., 2022; Afyon et al., 2017; Uluç & Durukan, 2023). Studies presenting contradictory findings were also considered.

In their study investigating the effects of 8-week core strength training on the football skills of male football players aged 13-14, Alpşahin and Mendeş (2019) found no statistically significant difference in favor of the experimental group in the speed and agility parameters.

In a study investigating the effects of an 8-week core strength training program on speed, agility, and balance in male football players aged 14–16, no statistically significant improvements were observed in speed and agility for the core training group.

Similarly, in the present study, analysis of 20-meter sprint performance between pre- and post-tests in the football and football+core groups indicated no significant differences, supporting previous findings that core exercises may not significantly enhance speed.

Doğanay et al. (2020) investigated the effects of core training on speed, quickness, and agility in 24 young male football players. After eight weeks, the experimental group demonstrated statistically significant improvements in quickness and agility ($p < 0.05$), whereas no significant changes were observed in speed performance ($p > 0.05$).

Aslan and Kahraman (2023) examined the impact of core exercises on multiple biomotor parameters in male soccer players. The study reported statistically significant improvements in the experimental group's vertical jump, 30-meter sprint, and agility performance between pre- and post-test measurements.

When the literature is examined, our research is consistent with the literature. It has been reported that regular core exercises positively affect strength, speed, and agility parameters. In conclusion, it was determined that core exercises applied to soccer players positively affect vertical jump, 30-second sit-ups, 30-second push-ups, 20-meter sprint, and Illinois agility performance.

While the study showed a mathematically positive increase, we believe there may be several reasons why this increase was not statistically significant. These could include: the study group consisting of inexperienced athletes, the low average age of the study group, and the insufficient duration and frequency of the exercises to produce a positive effect. It is recommended that footballers use core exercises to improve their athletic performance. Future research is advised to select sample groups from athletes of different genders, age groups, and experience levels.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding this article.

Ethics Committee Report

The ethical evaluation was approved by the Batman University Scientific and Publication Ethics Committee with the decision numbered 2024/08, dated 31.10.2024.

Authors' Contribution

Study Design: FBB, VS, MB

Data Collection: VS, FBB

Statistical Analysis: FBB, MB

Manuscript Preparation: FBB, MB, VS

Funding Acquisition: FBB, MB, VS

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