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ORIGINAL RESEARCH

The effect of four-week strength, speed, and endurance training on some blood parameters in amateur soccer players

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Abstract. This study aimed to determine the effects of four-week strength, speed, and endurance training on some biochemical parameters and hormone levels in regional amateur league soccer players. Eighteen male soccer players (age: 21.72±1.81) playing in the regional amateur league during the 2023-2024 Turkish Football Federation football season participated voluntarily. The players were divided into two groups: experimental (9) and control (9) using simple random sampling. The players in the experimental group underwent strength, speed, and endurance training in addition to basic soccer training for four weeks during the competition period, while the players in the control group only underwent routine soccer training. Blood samples were collected from the players before and after the four-week training sessions and analyzed in a laboratory setting. The SPSS software was used for statistical analysis of the data. A paired samples t-test was used to analyze normally distributed data. According to the research findings, a significant difference was found in the LDL cholesterol and creatinine parameters between the pre-test and post-test values of the football players in the experimental group, and in the calcium parameter in the football players in th e control group ($p<0.05$). In conclusion, it was determined that four weeks of strength, speed, and endurance training applied to regional amateur league football players reduced LDL cholesterol and creatinine levels.

Introduction

Football is one of the most popular sports worldwide and appeals to a wide audience in our country. This sport, which is becoming increasingly widespread and popular, is undergoing continuous development thanks to the interaction between science and sports science (Adalı, 2019). Football is a sport that requires a significant amount of game intelligence, demonstrating not only physical characteristics but also cognitive strength (Kahraman and İşlen, 2023). Advances in football's dynamics and rising training standards positively impact performance while also enhancing viewing pleasure and providing spectators with a more enjoyable experience (Karagöz et al., 2017). Today, the game of football continues to be a center of attention, intensifying competition. In parallel with this increasing competition, teams are experimenting with different approaches to technical, tactical, and conditioning development to gain an edge over one another. Since athletic performance in football players is multifaceted, development is a very challenging process (Weldon et all., 2021). Since football is a sport played on a large playing field with a large group of players, the duties and responsibilities of each player vary. This situation necessitates that football players have different physical and physiological needs. Compared to other sports, football exhibits significant differences in this regard, requiring players to possess various physical attributes such as endurance, speed, agility, and strength (Kartal et al., 2016). Comparing the individual physical characteristics of football players is an important source of information in terms of helping to determine their strengths and weaknesses, organizing training programs and taking strategic measures before competitions (Baştürk, 2018). In the modern understanding of football, the physical and athletic structures of goalkeepers, defenders, midfielders, and forwards, which previously exhibited significant differences, have become increasingly similar (Pilça and Altun, 2019). Now, football players playing in all positions are expected to have basic motor skills at a high level, and it has become an indispensable part of the game that the defense

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supports the offense when necessary and the offensive players contribute to the defense (Apaydın et al., 2022).

Football players must use both their lower and upper limbs intensively during play. Movements such as running, jumping, and hopping are fundamental and dominant activities for the lower extremities, while movements such as holding, pushing, and goalkeeper saves require upper extremity strength and skill (Orhan, 2023). While the volume, mass and cross-sectional area of the arm and leg muscles directly affect the force and power produced, it is known that the increase in volume in these muscle groups also provides improvement in anaerobic performance and strength values (Marangoz and Gençay, 2019). While the energy system used by football players during competition is predominantly aerobic, it can be said that the decisive attacks, kicks, and sprints are fueled by the anaerobic energy system (Bangsbo et al., 2006; Reilly et al., 2000).

In football, it is possible to observe the alternation of high, moderate, and low-intensity loads in short intervals. Although basic energy needs are primarily met by aerobic metabolism, the high-intensity sprints, sudden accelerations, changes of direction, and explosive power movements that are decisive during matches are supported by anaerobic energy systems (Stolen et al., 2005). Therefore, football players need both aerobic endurance and anaerobic capacity to maximize their performance (Aslan, 2012). In this context, football is a type of exercise that utilizes all energy systems in a complex manner and demonstrates the integration of all energy systems (Silva et al., 2022; Stolen et al., 2005). In football, where development is considered multifaceted, it is possible to observe increases or decreases in the blood levels of some biochemical variables that determine athletic performance due to training.

Different types of exercise are known to have different physical, physiological, and biochemical effects. We believe that identifying and discussing the biochemical outcomes resulting from the sequential application of three training protocols with distinct characteristics will contribute to the sports literature. Our study aims to determine the effects of different training methods applied over four weeks on certain biochemical parameters in football players playing in the regional amateur league.

Material and Method

The study was designed to determine the changes in some blood parameters affecting athletic performance in regional amateur football players following different training methods applied over four weeks. Eighteen male football players ($\bar{X}$age: 21.72±1.81) playing in the regional amateur league of the Turkish Football Federation during the 2023-2024 football season participated in the study as volunteers. The purpose and procedures of the study were thoroughly explained to all participants, and their voluntary participation was confirmed through the signing of an informed consent form. Ethical approval for the research was obtained from the Scientific Research and Publication Ethics Committee of Muş Alparslan University, in accordance with the decision numbered 158532, dated October 16, 2024. The study was conducted in full compliance with institutional ethical guidelines and international standards for research involving human participants, thereby ensuring the protection of participants' rights, privacy, and well-being throughout the research process. In this study, participants were assigned to groups using a random sampling method. Initially, the names of all volunteers were recorded on a list, and each participant was assigned a numerical code to ensure confidentiality. Subsequently, a computer-assisted random number generator was employed to allocate participants to the experimental and control groups based on the principle of equal probability. This procedure was designed to minimize researcher bias and to establish baseline homogeneity between groups. Following the random assignment, demographic variables such as age and sex, as well as baseline performance measures, were compared between groups. Statistical analyses confirmed that there were no significant differences in the initial characteristics of the experimental and control groups. This outcome enhanced the internal validity of the study and increased the reliability of the findings. Moreover, conducting the randomization process in a transparent and systematic manner strengthened the scientific rigor of the research and contributed to the generalizability of the results.

Participants' heights were measured in cm with a tape measure, while barefoot, and their body weights were measured using a TANİTA MC 780 device. Blood samples were collected from the antecubital veins of the participants at the physical therapy outpatient clinic of Muş State Hospital under the supervision of a specialist physician, two days before the initiation of training and two days after the completion of the four-week training program. The blood samples were obtained from the participants in a postprandial state and under resting conditions. The centrifuged blood samples were sent to the Biochemistry Laboratory of Muş State Hospital for analysis, and the results were recorded as numerical values. For four weeks, on Tuesdays, Wednesdays, and Thursdays, the experimental group received 30 minutes of different training protocols (speed, strength, and endurance) in addition to one hour of soccer training. The control group received only 90 minutes of soccer training. The players were given a rest every Monday and Saturday, and on Fridays, both groups only trained for soccer, and on Sundays, they played a soccer match. Before the training sessions, they underwent a 5-minute stretching or special warm-up session for each muscle group.

Statistical Analysis

The statistical analyses were performed using the SPSS software package. Data normality was assessed with the Shapiro–Wilk test, and variables meeting the normality assumption were analyzed with the Paired Samples t-test. A significance level of $p < 0.05$ was adopted for all statistical comparisons. Since multiple parameters were tested simultaneously in this study, the increased risk of Type-I error was taken into account. To address the inflation of false-positive findings due to multiple comparisons, Bonferroni correction was applied and the results were interpreted accordingly.

Results

Table 1. Training Programs of the Experimental Group

Strength Training Program of the Experimental Group					
Movement	**Number of Sets**	**Number of Repetitions**	**Intensity (%Max)**	**Rest between sets**	**Rest between moments**
Bench Press	5	1-5	%85-100	90 seconds	3 minutes
Shoulder Press	5	1-5	%85-100	90 seconds	3 minutes
Squat press	5	1-5	%85-100	90 seconds	3 minutes
Speed Training Program of the Experimental Group					
Movement	**Number of Sets and Repetitions**		**Intensity (%Max)**	**Rest between sets**	**Rest between moments**
10m sprint	8 X 10 m		%90	90 seconds	3 minutes
15m sprint	7 X 15 m		%90	90 seconds	3 minutes
20m sprint	6 X 20 m		%90	90 seconds	3 minutes
Endurance Training Program of the Experimental Group					
Movement	**Number of Sets**	**Number of Repetitions**	**Intensity (%Max)**	**Rest between sets**	**Rest between moments**
Bench Press	3	20	%50	90 seconds	3 minutes
ShoulderPress	3	20	%50	90 seconds	3 minutes
Squat Press	3	20	%50	90 seconds	3 minutes

Table 2. Descriptive Characteristics of the Participants

	Experimental Group (N=9)			**Control Group (N=9)**		
General Characteristics	**Mean±SD**	**Min.**	**Max.**	**Mean±SD**	**Min.**	**Max.**
Age (years)	22,11±1,96	19,00	25,00	21,33±1,66	18,00	24,00
Height (cm)	180,11±4,91	172,00	186,00	174,00±5,94	168,00	187,00
Body Weight (kg)	74,89±7,75	62,00	83,00	66,23±5,87	54,00	72,60

Table 3. Pre- and Post-Test Findings on the Biochemical Parameters of the Experimental Group

Biochemical Parameters		N	Mean.	S.D.	t	P	Cohen's d	Cl _Low	Cl_high
Creatinine (mg/dl)	Pre-Test	9	0,96	0,13	2,823	**,022***	0,91	0,141	1,741
	Post-Test	9	0,89	0,11					
AST (u/l)	Pre-Test	9	22,00	3,46	1,104	,302	0,368	-0,31	1,046
	Post-Test	9	20,33	2,96					
ALT (u/l)	Pre-Test	9	18,67	5,74	,100	,923	0,033	-0,62	0,687
	Post-Test	9	18,56	8,11					
Cholesterol (mg/dl)	Pre-Test	9	133,44	21,18	,409	,693	0,136	-0,52	0,793
	Post-Test	9	132,22	18,56					
HDL-Cholesterol (mg/dl)	Pre-Test	9	47,67	5,28	-,271	,793	-0,09	-0,745	0,564
	Post-Test	9	47,98	5,32					
LDL-Cholesterol	Pre-Test	9	69,11	15,77	4,914	**,001***	1,638	0,603	2,673
	Post-Test	9	59,89	17,88					
Urea (mg/dl)	Pre-Test	9	25,78	4,49	-,248	,810	-0,083	-0,737	0,572
	Post-Test	9	26,11	6,27					
Iron binding capacity (ug/dl)	Pre-Test	9	234,44	38,28	,469	,651	0,156	-0,501	0,814
	Post-Test	9	227,67	52,78					
Calcium (mg/dl)	Pre-Test	9	9,64	0,18	1,414	,195	0,471	-0,222	1,164
	Post-Test	9	9,58	0,25					
Potassium (mmol/l)	Pre-Test	9	4,62	0,53	1,314	,225	0,438	-0,25	1,126
	Post-Test	9	4,43	0,36					
Vitamin B12 (pg/ml)	Pre-Test	9	335,11	165,73	-,498	,632	-0,166	-0,824	0,492
	Post-Test	9	345,78	153,46					
Ferritin (ng/ml)	Pre-Test	9	57,02	44,68	1,008	,343	0,336	-0,338	1,01
	Post-Test	9	50,69	32,84					

*p<0,05

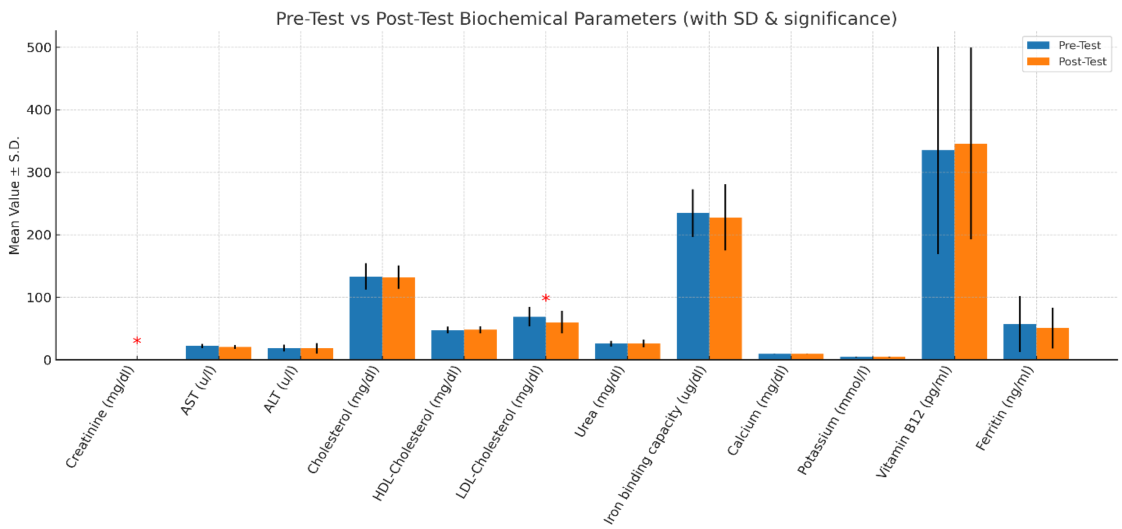

Figure 1. The Mean Values Of The Pre-Test and Post-Test Measurements of The Experimental Group

Table 4. Hormone Parameters of the Experimental Group

Hormones		**N**	**Mean.**	**S.D.**	**t**	**p**	**Cohen's d**	**Cl _Low**	**Cl_high**
TSH (mlu/l)	Pre-Test	9	2,17	0,91	-,146	,888	-0,049	-0,702	0,605
	Post-Test	9	2,23	1,75					
Free T3 (pg/ml)	Pre-Test	9	3,71	0,22	-2,286	,052	-0,762	-1,515	-0,009
	Post-Test	9	3,94	0,21					
Free T4 (ng/dl)	Pre-Test	9	1,30	0,21	1,186	,270	0,395	-0,286	1,077
	Post-Test	9	1,24	0,16					

Table 5. Pre- and Post-Test Findings on the Biochemical Parameters of the Control Group

Biochemical Parameters		**N**	**Mean.**	**S.D.**	**t**	**p**	**Cohen's d**	**Cl _Low**	**Cl_high**
Creatinine (mg/dl)	Pre-Test	9	0,95	0,11	1,033	,332	0,344	-0,33	1,019
	Post-Test	9	0,93	0,10					
AST (u/l)	Pre-Test	9	19,00	5,02	-,811	,441	-0,27	-0,937	0,396
	Post-Test	9	20,22	5,83					
ALT (u/l)	Pre-Test	9	16,30	5,90	-1,196	,266	-0,399	-1,081	0,283
	Post-Test	9	17,67	6,08					
Cholesterol (mg/dl)	Pre-Test	9	132,19	19,79	-,382	,713	-0,127	-0,784	0,529
	Post-Test	9	133,11	20,27					
HDL-Cholesterol (mg/dl)	Pre-Test	9	47,86	11,30	-1,528	,165	-0,509	-1,209	0,19
	Post-Test	9	49,39	10,56					
LDL-Cholesterol	Pre-Test	9	61,54	14,62	-,830	,431	-0,277	-0,944	0,391
	Post-Test	9	63,32	16,48					
Urea (mg/dl)	Pre-Test	9	26,33	3,43	-1,333	,219	-0,444	-1,133	0,244
	Post-Test	9	27,67	4,58					
Iron binding capacity (ug/dl)	Pre-Test	9	222,78	44,78	-,904	,392	-0,301	-0,971	0,368
	Post-Test	9	231,56	56,61					
Calcium (mg/dl)	Pre-Test	9	9,57	0,39	-3,612	**,007***	-1,204	-2,084	-0,324
	Post-Test	9	10,01	0,21					
Potassium (mmol/l)	Pre-Test	9	4,41	0,46	1,182	,271	0,394	-0,287	1,075
	Post-Test	9	4,21	0,18					
Vitamin B12 (pg/ml)	Pre-Test	9	290,11	123,56	,140	,892	0,047	-0,607	0,7
	Post-Test	9	288,56	104,11					
Ferritin (ng/ml)	Pre-Test	9	50,02	30,21	-1,093	,306	-0,364	-1,042	0,313
	Post-Test	9	50,90	30,34					

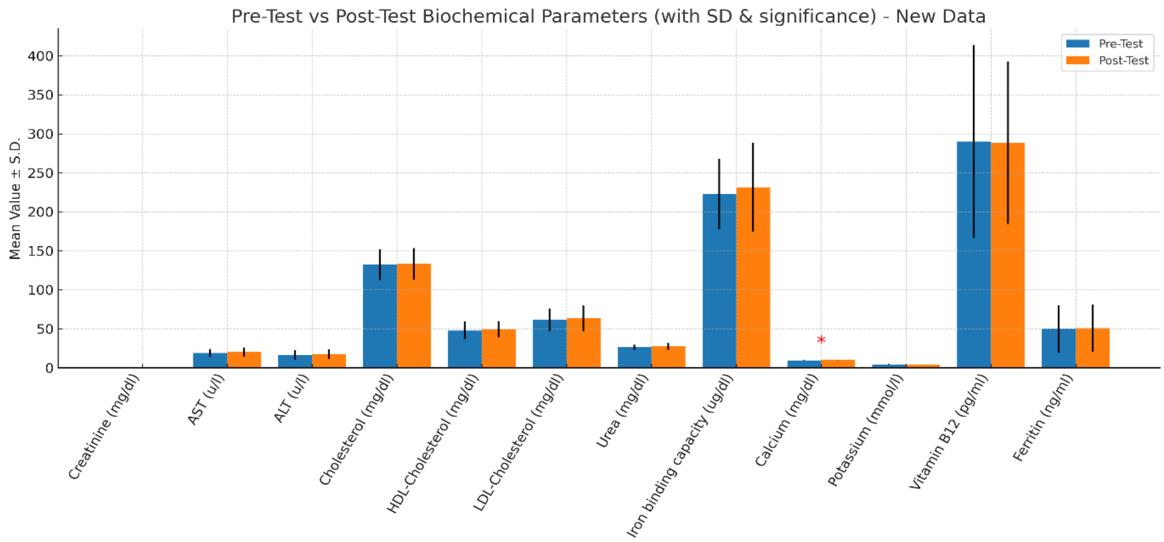

Figure 2. The Mean Values Of The Pre-Test and Post-Test Measurements of The Control Group

Table 6. Hormone Parameters of the Control Group

Hormones		N	Mean.	S.D.	t	p	Cohen's d	Cl _Low	Cl_high
TSH (mlu/l)	Pre-Test	9	2,08	0,50	-,569	,585	-0,19	-0,85	0,47
	Post-Test	9	2,11	0,52					
Free T3 (pg/ml)	Pre-Test	9	3,86	0,13	1,036	,331	0,345	-0,33	1,02
	Post-Test	9	3,82	0,22					
Free T4 (ng/dl)	Pre-Test	9	1,23	0,17	,855	,417	0,285	-0,383	0,953
	Post-Test	9	1,22	0,18					

Table 1 the training program applied to the experimental group was designed to improve strength, speed, and endurance capacities of the football players. The strength training plan included multi-joint resistance exercises such as the bench press, shoulder press, and squat press, performed at high intensity (85–100% of 1RM) with low repetitions (1–5 reps) and adequate rest intervals (90 seconds between sets and 3 minutes between exercises).

The speed training protocol consisted of repeated short-distance sprints (10 m, 15 m, and 20 m), performed at 90% of maximum effort. The number of repetitions decreased as the sprint distance increased, while recovery times were standardized to 90 seconds between sets and 3 minutes between sprint variations.

The endurance training sessions were structured with resistance exercises (bench press, shoulder press, and squat press) performed at moderate intensity (50% of 1RM) with high repetitions (20 reps per set), allowing players to develop muscular endurance. Similar rest intervals were maintained to ensure consistency across training modalities.

Descriptive statistics regarding the general characteristics of the regional amateur league football players participating in the study are presented in Table 2.

Table 2 presents the comparison of pre-test and post-test values of the biochemical parameters of the football players in the experimental group, while Table 3 provides the comparison of pre-test and post-test values related to the hormonal parameters.

According to the findings in Table 2, there was a significant difference in the biochemical parameters of Creatinine and LDL-Cholesterol between the pre-test and post-test values of the football players in the experimental group ($p<0.05$), while no significant difference was found in the other parameters ($p>0.05$). The football players' Creatinine and LDL-Cholesterol values decreased in the post-tests. These results indicate that the four-week training program produced a large and statistically reliable reduction in creatinine and LDL-cholesterol levels, suggesting meaningful physiological adaptations in muscle metabolism and lipid regulation. However, the effect sizes for other biochemical parameters were small and their wide confidence intervals suggest that these findings should be interpreted with caution. Overall, the intervention appears to have selectively influenced specific biochemical markers rather than inducing broad systemic changes.

According to the findings in Table 3, no significant difference was found between the pre-test and post-test values for the hormonal parameters of the football players in the experimental group ($p>0.05$). These results indicate that the training intervention had negligible effects on TSH levels, while a medium-to-large effect was observed for Free T3 concentrations, approaching statistical significance. Free T4 values demonstrated only a small effect size with wide confidence intervals, suggesting limited reliability. Overall, the findings imply that short-term training may have a modest influence on thyroid function, particularly on Free T3, but further research with larger samples and longer interventions is required to confirm these outcomes.

Table 4 presents the comparison of pre-test and post-test values for the biochemical parameters of the football players in the control group, while Table 5 displays the corresponding comparison for the hormonal parameters.

According to the findings in Table 4, there was a significant difference in the calcium parameter between the pre-test and post-test values of the football players in the control group ($p<0.05$), while no significant difference was found in the other parameters ($p>0.05$). The calcium levels of the football players increased in the post-test. Table 4 presents the effect sizes (Cohen's d) and 95% confidence intervals for the biochemical parameters of the experimental group. The results indicate that most parameters demonstrated small or negligible effect sizes. For instance, the reduction observed in creatinine levels corresponded to a small-to-moderate effect ($d = 0.34$), although the confidence interval crossed zero, suggesting that the effect is not statistically reliable. Similarly, AST, ALT, cholesterol, and HDL-cholesterol values showed small-to-moderate effect sizes, yet their wide confidence intervals indicate unstable effects. Taken together with the non-significant p-values, these findings suggest that the four-week training program produced only limited and inconsistent changes in the biochemical markers of the football players.

According to the findings in Table 5, no significant difference was found between the pre-test and post-test values in the hormone parameters of the football players in the control group ($p>0.05$). The analysis of hormonal parameters indicated negligible to small effect sizes across TSH, Free T3, and Free T4 values. None of the observed changes reached statistical significance, and the wide confidence intervals crossing zero suggest that the effects were not reliable. These findings imply that the short-term training intervention did not produce meaningful alterations in thyroid-related hormonal responses in the participants.

Discussion and Conclusion

In our study, a statistically significant decrease was observed in Creatinine (mg/dl) and LDL-Cholesterol in the experimental group, while no differences were detected in other biochemical parameters (AST, ALT, Cholesterol, HDL, Urea, Iron-Binding Capacity, Calcium, Potassium, Ferritin, B12) and hormone parameters (TSH, Free T3, Free T4). A statistically significant increase was observed only in Calcium (mg/dl) in the control group, while no differences were detected in other parameters.

While a statistically significant decrease in serum LDL levels was observed in the experimental group after training, no significant difference was observed in serum cholesterol and HDL levels. No difference was observed between the pre-test and post-test values of serum cholesterol, HDL, and LDL in the control group. A study on adolescent women reported that HDL blood plasma levels in athletes increased significantly compared to sedentary women, while there was no significant difference between LDL and cholesterol blood plasma levels in athletes and sedentary individuals (Bilici, 2020). It has been reported that a four-week training program in elite female taekwondo athletes caused a significant decrease in cholesterol levels (Çakmakçı and Pulur, 2008). Another study reported that there was no statistically significant difference in pre- and post-exercise cholesterol values in marathon athletes (Kratz et al., 2002). It has been reported that 7 weeks of stair training in sedentary female individuals caused a significant increase in serum HDL levels and a significant decrease in LDL levels (Colin et al., 2000). A study examining the effects of aerobic exercise on blood lipid levels in young and middle-aged women found that total cholesterol and LDL cholesterol levels decreased significantly after exercise, while HDL levels increased (Karacan and Çolakoğlu, 2003). Another study reported that intense and vigorous physical activity performed by athletes increased serum HDL and total cholesterol levels

(Kaynar et al. 2016). While the literature contains similar results to our study, there are also studies that generally disagree with our results. This may be due to the shorter planned training duration.

Creatinine, used as a marker of kidney function, is also a waste product produced during muscle metabolism and excreted by the kidneys. Serum creatinine production occurs spontaneously when muscle cells become dehydrated, independent of enzymatic effects (Wyss and Kaddurah-Daouk, 2000; Kashani et al., 2020). The significantly lower post-training creatinine value in the experimental group in our study may be related to muscle metabolism. No significant difference was found between the pre-test and post-test plasma levels of urea and vitamin B12 in the experimental and control groups. Bilici (2020) reported no significant difference between the urea and vitamin B12 blood plasma levels of athletes and sedentary individuals. Another study conducted on trained and sedentary women reported no significant difference in vitamin B12 concentrations between the two groups (Woolf et al., 2017). A review of the literature generally indicates that physical exercise has no chronic effect on plasma levels of the vitamin (Bilici, 2020). Blood urea concentration has been reported to increase due to increased oxygen consumption and metabolic rate during physical activity, but returns to normal after exercise. In this case, it can be said that blood urea concentration changes due to the acute effects of exercise (Öztürk, 2009). Literature studies generally indicate that potassium levels change due to the acute effects of exercise (Gülnar, 2012; Singh and Sirisinghe, 1999). Our study results indicate that training did not have a chronic effect on potassium levels in the experimental and control groups.

Many studies have shown that exercise promotes increases in bone density, bone mass, and bone mineral content (Harrison, 1984; Lanyon and Rubin, 1983). Ljunghall and colleagues (1984) reported a significant increase in calcium concentration in parallel with increased exercise workload. Another study reported that exercise mobilizes calcium stores and that serum ionized calcium increases significantly with exercise at 50% of maximal aerobic capacity (VO2 max) (Henderson et al., 1989). The significant increase in calcium concentration in the control group after exercise in our study may be due to the optimal training load. In this context, it can be said that optimal exercise load contributes to skeletal structure.

In our study, no significant difference was found between the pre-test and post-test plasma levels of AST and ALT in the experimental and control groups. When studies in the literature were examined, Bilici (2020) reported that AST blood plasma levels in adolescent female athletes were significantly increased compared to sedentary women, while there was no significant difference between the ALT plasma levels of both groups. In a study conducted on kickboxers, it was stated that AST and ALT values increased significantly due to the acute effect of severe and intense physical activity (Kaynar et al. 2016). In a study on elite female taekwondo athletes, blood samples taken before and immediately after a four-week training program were compared, and a significant increase in AST and ALT levels was noted (Çakmakçı and Pulur, 2008). Kratz et al. (2002) reported a significant increase in AST and ALT plasma levels after exercise. In addition to liver damage, AST and ALT plasma levels are elevated, particularly in cases of cardiac and skeletal muscle disorders or injuries (Bilici, 2020). Our study results generally appear to be inconsistent with those reported in the literature. In this context, it can be argued that the short duration of the training sessions implemented in our study, which were not intense enough to cause any damage to skeletal muscle, resulted in normal serum AST and ALT levels in both groups

TSH (Thyroid Stimulating Hormone) is involved in the initiation of the release of T3 and T4 hormones. T3 and T4 hormones also participate in protein synthesis. Hormones have different responses to different training types. The effects of aerobic training on thyroid hormone have not been adequately explained (Gençoğlu and Akkuş, 2020). However, a study on weightlifters reported that intense strength training decreased the serum concentrations of TSH, T4, and T3 hormones (Pakarinen et al., 1991). Results in the literature generally indicate that exercise stress reduces thyroid gland function and TSH secretion (Gençoğlu and Akkuş, 2020). In our study, no significant differences were observed between pre- and post-training hormone values in either group. In this context, it can be said that the short-term, different training loads applied in our study did not have any chronic effects on thyroid hormones in our study population.

Taken together, the findings of this study indicate that while short-term training may induce modest improvements in certain biochemical markers such as LDL-cholesterol and creatinine, its overall impact on broader biochemical and hormonal parameters appears limited, underscoring the need for longer and more intensive interventions to fully elucidate exercise-induced physiological adaptations in football players.

Despite its contributions, this study has certain limitations. The small sample size (n = 18) reduces the statistical power and limits the generalizability of the findings. The intervention lasted only four weeks, which may not have been sufficient to detect long-term or cumulative adaptations. Additionally, only a limited number of biochemical and hormonal variables were measured, and the inclusion of further markers, such as oxidative stress parameters, inflammatory cytokines, or anabolic/catabolic hormones, would have provided deeper insights. Moreover, external factors such as dietary intake, sleep quality, psychological stress, and uncontrolled daily physical activity may have influenced the biochemical responses. Finally, the study population consisted exclusively of young male football players, limiting the applicability of the results to athletes of other ages, sexes, or sporting disciplines.

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Conflict of Interest

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

Ethics Committee Approval Report

The ethical approval for this study was obtained from the Muş Alpaslan University Scientific Research and Publication Ethics Committee (Date: 18.09.2024, Decision No: 16).

Authors' Contribution

Study Design: SO, MFB
Data Collection: SO, MFB
Statistical Analysis: SO, MFB
Manuscript Preparation: SO, MFB
Funding Acquisition: SO, MFB

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