ORIGINAL ARTICLE

Effects of high intensity interval training on trace minerals and physiological parameters in tennis players

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim This study investigated the effects of HIIT (high-intensity interval training) implementations on some serum elements, resting heart rate, total body weight, and BMI parameters in tennis players.

Material and Methods The study group consisted of 20 athletes (aged 18-22) who were actively playing tennis. The athletes were divided into experimental (n=10) and control (n=10) group. To assign participants to these groups homogeneously, preliminary measurements were made before the study, and the results were used for clustering analysis. While the control group continued their regular tennis training, the experimental group was given additional HIIT three days a week besides regular tennis training. Measurements of BMI, resting heart rate, and body weight were taken, and serum samples were collected before and after training from both groups. The SPSS package program was used in data analysis. The level of significance was set at $p<0.05$ in the tests. Participants showed significant differences in sodium, calcium, iron, resting heart rate, weight, and BMI parameters between groups ($p<0.05$).

Results However, no significant differences between the groups were found in potassium, chlorine, and magnesium parameters ($p>0.05$). The within-group measurements of sodium, calcium, resting heart rate, weight and BMI levels decreased in the experimental group in the post-test, while iron levels were higher in the post-test compared to the pre-test value ($p<0.05$). On the other hand, the pre-test and post-test values were similar within the control group, and there were no significant differences ($p>0.05$).

Conclusions Training remodelled with HIIT implementation can affect athletes' element levels, BMI, total body weight, and resting heart rate. In addition, the increase in iron levels due to HIIT in the experimental group was important. We believe that this may affect both muscle contraction functions and the efficiency performance output. Lastly, due to the decrease of calcium and sodium elements with HIIT implementations, we suggest that HIIT applications should not be performed unsupervised. In addition, by tracking the element levels of athletes, they should be supported with supplements or nutritional meals in line with expert advice when necessary.

Keywords: tennis, HIIT, element, resting pulse, total body weight, BMI

Introduction

With a changeable game duration (90 minutes on average) and many viewers around the world, tennis is an intermittent Olympic sports branch characterized by repeated high-intensity accelerations, slowdowns, and directional and stroke changes [1]. The effort to achieve success in this Olympic branch requires a substantial mechanical load process for the organism. In this respect, decreased levels of elements such as sodium, potassium, calcium, and magnesium can be observed by sweating due to training-based mechanical loads. These decreases in elements may vary depending on the type of sport, the intensity of exercise load, duration, and climate conditions. It has been stated that the loss of elements is greater in summer months and loads with more extended periods, and in the event of element loss, they should be replenished with normal or concentrated food. Otherwise, it is emphasized that problems such as cramps, fatigue, and difficulty in breathing may occur, and the performance of the athlete will be adversely affected [2]. This is because by creating some chemical reactions, elements act as essential nutrients that spread throughout the body, positively affect the nervous system by activating the brain cells, and they also provide healthier functioning of the brain. It has been also stated that element levels are important in terms of athletes' performances, they have duties in structural processes and works of enzymes, and especially elements such as sodium, potassium, calcium, phosphorus, magnesium, and iron have important roles in stimulating muscle and nervous systems [3].

One of the most popular training practices of recent times, known as short-to-medium-term work lasting between 10 sec. and 5 min. and completed at an intensity higher than the anaerobic threshold,

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and in which a small amount of recovery is allowed for the next repetition, high-intensity interval training (HIIT) [4], is reported to affect serum element levels [5] and bone element density [6]. Furthermore, it is thought that interval training may also have impacts on physiological parameters such as resting pulse, BMI, and total body weight because interval training is reported to improve VO2max, decrease blood pressure [7], stimulate fatty acids more [8], and they might be an important means in weight loss [9].

This study investigates the effects of HIIT on the serum element levels, body composition, and resting heart rate of tennis athletes.

Material and Methods

Participants.

The study group consisted of 20 male athletes (aged 18-22) who were playing tennis regularly. The athletes were assigned into experimental (n=10) and control groups (n=10). Before beginning the study, clustering analysis was employed based on the results of preliminary measurements to ensure that participants were divided into homogenous groups. The participants were informed about the process, and their volunteer consent was obtained before starting the research.

Research Design.

The control group carried out their usual tennis training, whereas the experimental group performed additional high-intensity interval training (HIIT) three days per week along with their regular tennis exercises. The training performances were made on Tuesdays, Thursdays, and Wednesdays between 16:00-18:00, and they lasted for nine weeks. Before and after the training sessions, BMI, resting pulse, and total body weight measurements were obtained, and serum samples were taken.

Training Implementation

All athletes made warm-up running and stretching exercises with maximal heart rates (HRmax) of 130-140 for 10 minutes. Along with tennis training, the experimental group continued their HIIT training with an intensity of 70-75% VO_2 max for 1 week, and with 80-90% intensity VO2max from Week 2 until Week 9. The HIIT training was applied as a high-intensity and short-distance run. HIIT applications were implemented as 3 sets of 10 x 30 meter (15 seconds of rest after each 30 m.), and 2 minutes of breaks were given between the sets. During the main training phase, both groups were given the tennis training that is normally included in the annual plan. Both groups terminated their training sessions with cool-down runs (10 min.) and stretching exercises (10 min.).

Measurements

Biochemical Analyses

Fasting blood samples of 5 ml were taken at 9:00 AM from tennis players as venous blood by specialists at a private hospital. The blood samples were centrifugated with a Nüve-NF800 device for 5 minutes. The serum samples obtained were analysed using an autoanalyzer.

Body Weight

Bodyweight was measured with an electronic scale (Seca, Germany) that has ± 100 gr accuracy. During the measurements, the athletes were bare feet, wearing only shorts. The weights were recorded.

Body Mass Index (BMI)

The body mass indexes of the participants were analysed with the Tanita bioelectricity impedance device. The participant wore only shorts during this measurement.

Resting Heart Rate Measurements

Resting heart rates were measured through the Polar Vantage V smartwatch. The measurements were taken 1 minute after the tennis players woke up in the morning before they rose from bed when they were lying on their back without moving as three measurements within 1 minute. The average calculated for these three measurements was recorded as the resting pulse of the participants. The same procedure was applied after the training sessions were finished.

Statistical Analysis.

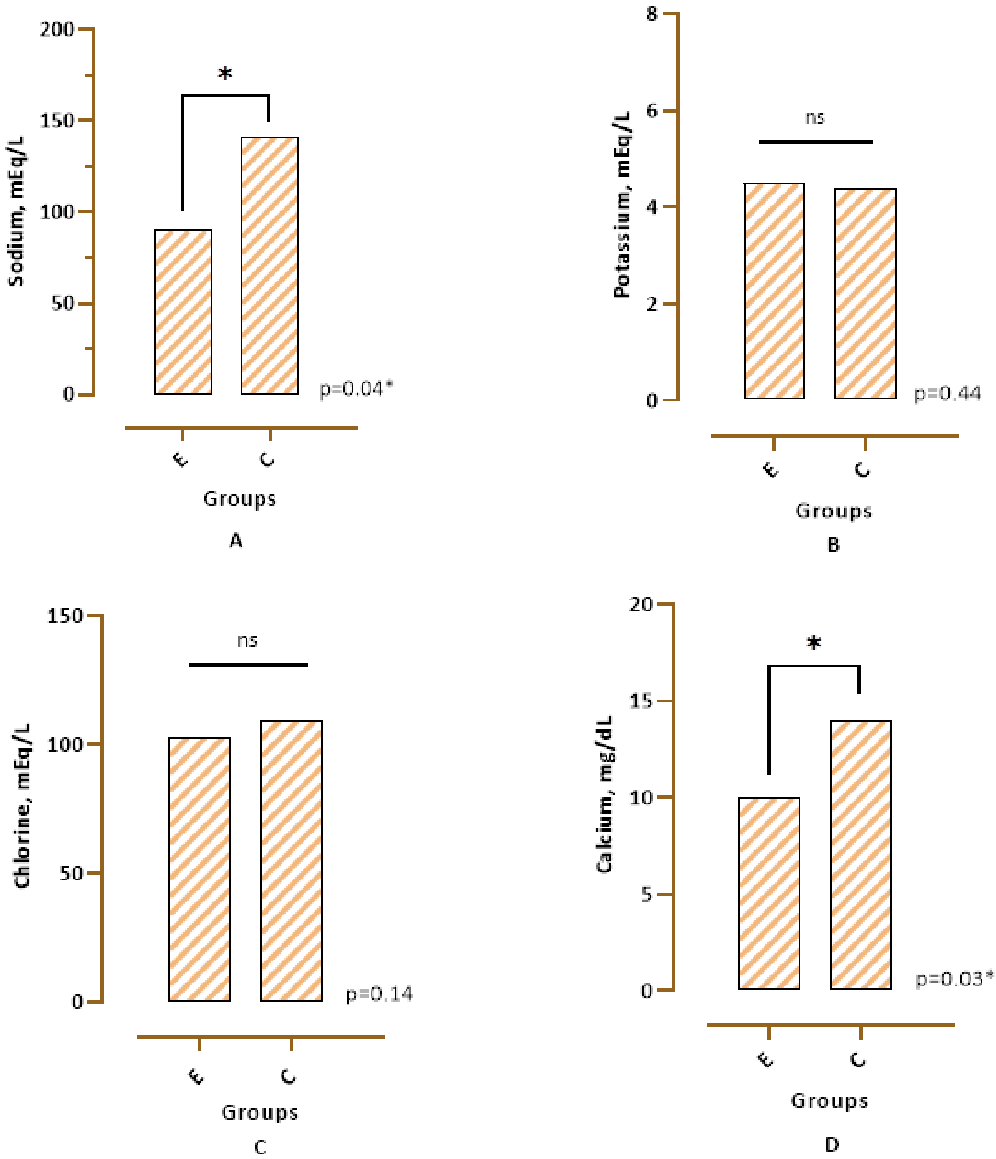
The data obtained were analysed using the SPSS 22.0 package program, and the seven-day free Graph Pad Prism 8 trial version was used for graphic representations. To assess the normality of the data, Kolmogorov-Smirnov test, histogram graphs, skewness and kurtosis, q-q plot, and stem-and-leaf plot were used, and the distribution was determined to be normal. The paired-samples t-test was applied from parametric tests for intra-group comparisons. Independent-samples t-test was used for post-test comparisons between groups. The level of significance was set as p<0.05 in all tests.

Results

Figure 1 displays the sodium (A), potassium (B), and chlorine (C) level in mEq/L; calcium (D) level in mg/dL. Figure 1, significant differences were found in sodium (Figure 1A), calcium (Figure 1D) levels in the post-test comparisons between the experimental and control groups (p<0.05). In contrast, no significant differences were found in chlorine (Figure 1B), and potassium (Figure 1C) levels (p>0.05).

Figure 2 displays the magnesium (E) level in mg/dL; phosphorus (F) level in mg/L; iron (G) level in ug/dL; BMI (I) in weight/height*m^2; TBW (I) in kg; RHR (I) in beats-per-minute (bpm) levels.

According to Figure 2, significant differences were found in iron (Figure 2G) levels in the post-test comparisons between the experimental and control groups (p<0.05). In contrast, no significant



*p<0.05, ns - nonsignificant; E – Experimental; C - Control

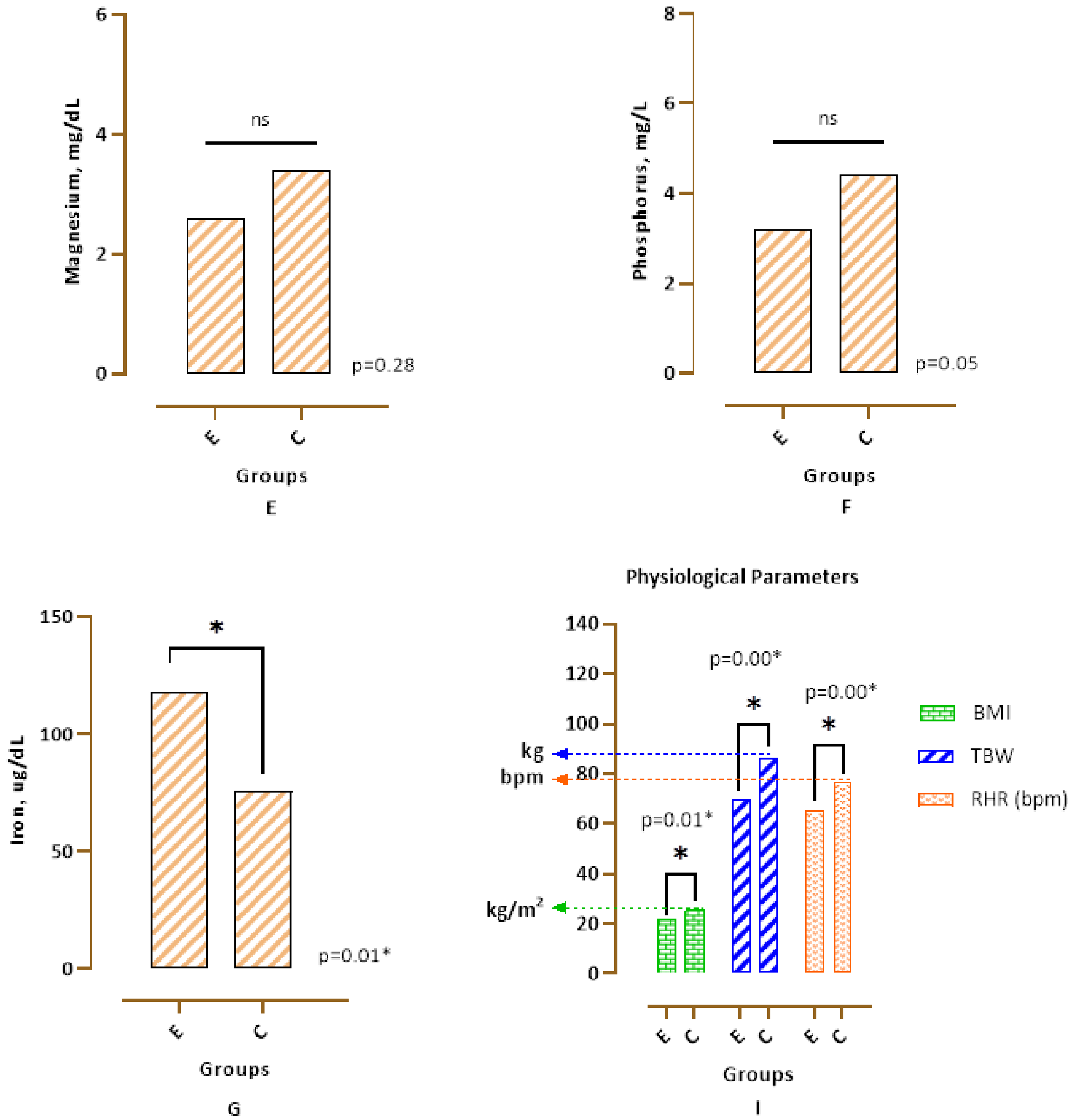
Figure 1. The figure below demonstrates the post-test serum elements sodium, potassium, chlorine and calcium (Experimental, Control; n=10).

differences were found in phosphorus (Figure 2F), magnesium (Figure 2E) levels. In addition, post-test comparisons between the experimental and control groups showed significant differences in BMI, and TBW and RHT (Figure 2I) levels ($p<0.05$).

Figure 3 demonstrates sodium (A), potassium (B), and chlorine (C) level in mEq/L; calcium (D) levels. According to Figure 3, significant differences were found between experimental within-group pre-test/post-test comparisons regarding sodium (Figure 3A) and calcium (Figure 3D) levels. This difference in the experimental group was due to the decrease in sodium and calcium levels ($p<0.05$). However, there were no significant differences in the levels of phosphorus (Figure 3C) and potassium (Figure 3B).

Figure 4 demonstrates magnesium (E) level in mg/dL; phosphorus (F) level in mg/L; iron (G) level in ug/dL; RHR (H) in beats-per-minute (bpm); TBW (H) in kg; BMI (H) in weight/height*m^2 levels.

According to Figure 4, significant differences were found between experimental within-group pre-test/post-test comparisons regarding iron (Figure 4G) levels. This difference in the experimental group was due to the increase in iron levels ($p<0.05$). However, there were no significant differences in the levels of phosphorus (Figure 4F) and magnesium (Figure 4E). Moreover, significant differences were found in the RHR, BMI, and TBW (Figure 4H) in the experimental group in a pre-test/post-test comparisons for the experimental and control group ($p<0.05$). On the other hand, no significant differences were observed in the pre-test/post-tests in the control group.



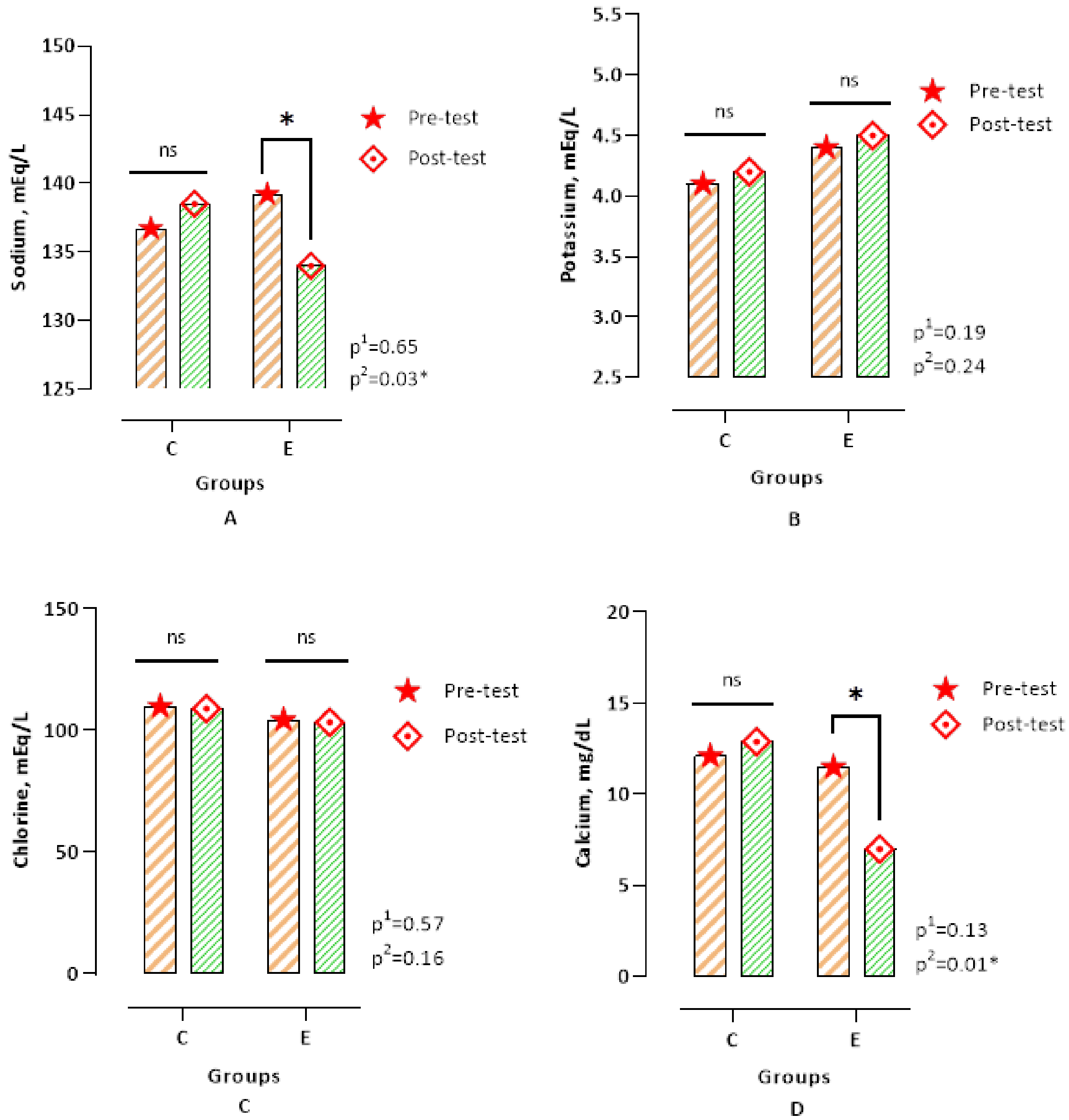
*p<0.05, ns – nonsignificant; E – Experimental; C – Control; BMI - Body mass index; TBW - total body weight and RHR - resting heart rate (bpm).

Figure 2. The figure below demonstrates the post-test serum elements magnesium, phosphorus, iron, BMI, TBW and RHT (Experimental, Control; n=10).

Discussion

When compared to the control group, statistically significant differences were determined in the experimental group in the parameters of total body weight, BMI, and resting heart rate in this study. Similarly, HIIT implementations were reported to regulate body fat ratio, body mass index and resting heart rate downwards [10]. It has been explained that this decrease in body fat rates may be associated with increased fat oxidation as a result of the need for more energy and more enzyme activation due to increased basal metabolic rate [11]. It is also emphasized that the positive relation of the concentrations of irisin and other hormones with HIIT protocols can open the door to fat oxidation [12]. Therefore, it is thought that the tennis + HIIT combination will improve parameters such as total body weight and BMI in athletes, and the decrease in the resting heart rate will support the efficiency output in the cardiac outflow, particularly in the experimental group.

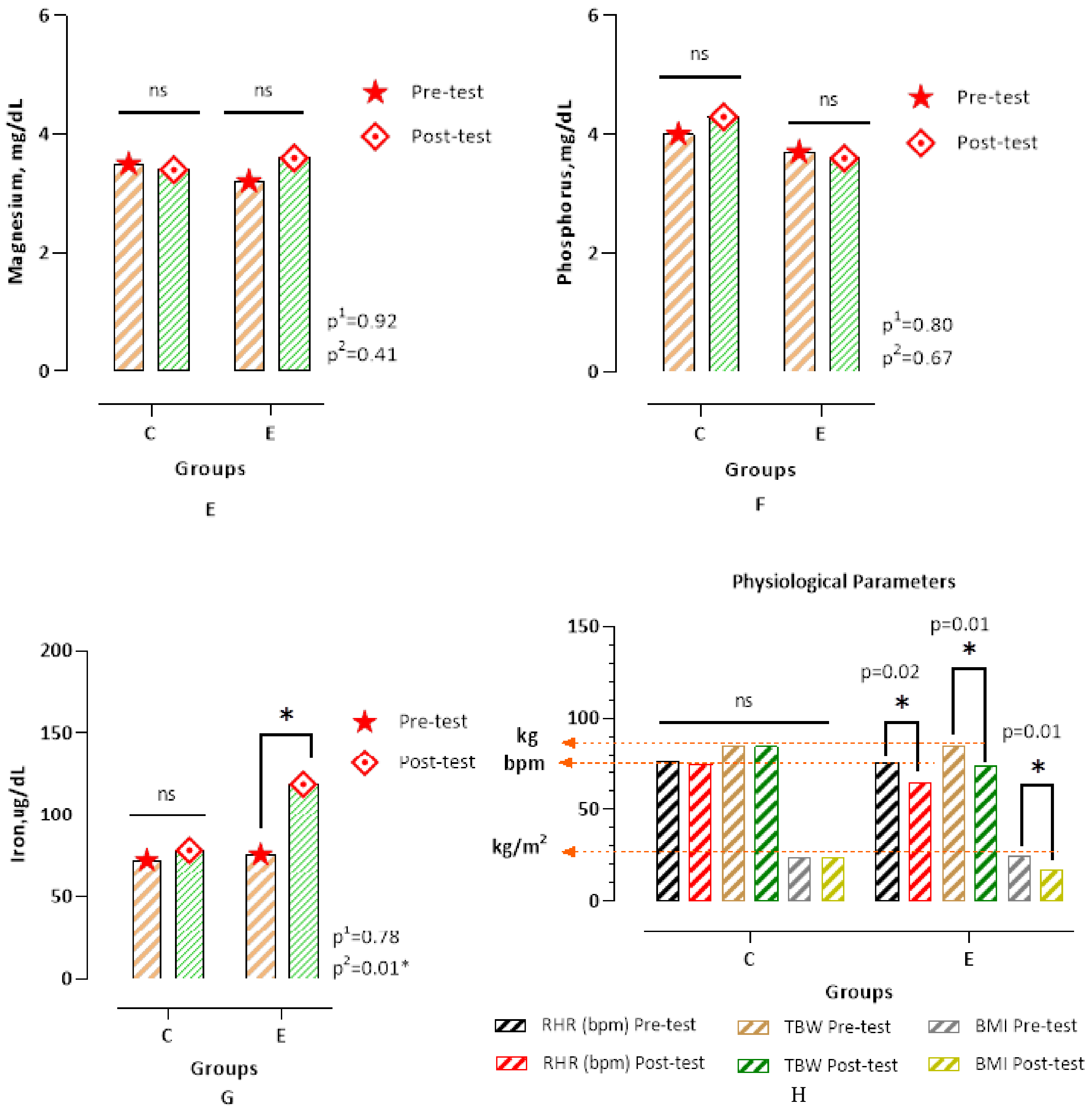
In this study, which examined the effect of HIIT applications on serum element levels, sodium, calcium, and iron levels were significant in the experimental group compared to the control group. However, the levels of phosphorus, magnesium,



*p<0.05, ns – nonsignificant; E – Experimental; C – Control; p^1 - control within-group pre-/post-test level of significance; p^2 - experimental within-group pre-/post-test.

Figure 3. The figure below demonstrates the within-group pre-test/post-test serum elements sodium, potassium, chlorine and calcium (Experimental, Control; n=10).

chlorine, and potassium were not significant between groups. While there was a significant increase in iron levels in athletes who performed HIIT in addition to tennis training, their sodium and calcium levels decreased. Therefore, athletes in the experimental group exposed to HIIT applications may have more oxygen transport in the blood due to an increase in their iron levels. This demonstrates that the athletes in the experimental group may demonstrate better performance compared to the control group in terms of efficiency. On the other hand, decreases in sodium and potassium levels in the experimental group can negatively affect the health and performance of athletes. For this reason, we think that tennis players should maintain sodium and potassium homeostasis to be ready for the next competition or training and to achieve better results. By dividing 20 young men who were 24-30 years old into two groups [13], applied continuous and intermittent training to the groups, and they had the same resistance training for 8 weeks with these HIIT applications. The researchers reported that both sodium and potassium levels decreased substantially in both groups (continuous and intermittent) at the end of the study, but there



*p<0.05, ns – nonsignificant; E – Experimental; C – Control; p[1] - control within-group pre-/post-test level of significance; p[2] - experimental within-group pre-/post-test; BMI - Body mass index; TBW - total body weight and RHR - resting heart rate (bpm).

Figure 4. The figure below demonstrates the within-group pre-test/post-test serum elements magnesium, phosphorus, iron, BMI, TBW and RHT (Experimental, Control; n=10).

was no significant difference. Besides standardized applications, a study examining the acute effects of additional HIIT-remodelled training method on element metabolism reported that pre-/post-test serum sodium levels decreased significantly while potassium levels increased significantly [14]. Regarding iron levels [15], did not observe any difference after three months of football training. In a study conducted recently, it has been stated that there was a significant decrease in iron levels at the end of a 1-month endurance training implementation [16]. We can state that these differences in iron levels may be due to the intensity of the training, duration, and characteristics of the participating group. However, as investigated in this current study, tennis workouts remodelled with HIIT in addition to standard practice can increase iron levels. As a result, this increase of iron in the blood can contribute to the transportation of more oxygen and increase efficient performance in the athlete.

By looking at the calcium levels in the study, it was seen that the calcium levels of the athletes in the experimental group decreased compared to the control group. Considering the literature, it is possible to encounter similar findings indicating that exercise affects calcium levels [17]. It is emphasized that calcium is especially necessary for neuronal and neuromuscular activity with the functioning of striped skeletal muscle and heart muscle cells and is important for performance output during physical activity and exercise depending on the provision of homeostatic control of this element [18]. However, when homeostatic control cannot be achieved and calcium levels decrease in the blood or the cells, undesired metabolic reactions may appear in the athletes. In this context, [19] maintained that the increased calcium levels in the cell may stimulate mitochondrial functions, ATP production, and oxidative stress, and lead to inflammatory conditions and eventually to cardiomyocyte necrosis. It has also been reported that low serum calcium levels, referred to as hypocalcaemia and known to cause heart failure [20], will rearrange myocardial excitation-contraction coupling [21]. It has been noted that reduced inside-outside cell calcium exchange will weaken blood circulation, impair cardiomyocyte contraction functions [20], and cause fatigue [22]. We think that, in this study, the decrease in the calcium levels of the athletes in the experimental group who performed HIIT in addition to tennis training may affect their skeletal muscles and heart muscle contraction functions. Therefore, by taking calcium-based nutrients or calcium supplements with their meals, we think that the athletes in the group who apply HIIT for calcium homeostasis can both regulate their performance outcomes, and reduce myocardial risk factors by improving contraction functions in the two muscle groups.

In this study, no significant difference was found in magnesium levels between the experimental and the control group. Today, it is stated that deficiency in magnesium levels will be rare even in clinical conditions, regardless of exercise [23]. Similar statements are found in studies focusing on the relationship between exercise and magnesium [24,25]. While the normal range of magnesium levels in healthy individuals is between 1.8 and 2.6 mg/dL, the average levels in the tennis players in this study were 2.4 mg/dL in the experimental group and 2.3 mg/dL in the control group. The magnesium levels of athletes in the experimental group were within the normal range, whereas those of the control group were above normal. However, there are controversial findings in other studies. Determined that the comparison between the pre-test and post-test serum magnesium levels of swimmers of 11-12 years of age revealed no significant differences, but there was a significant difference in urine magnesium levels [26]. maintained that magnesium serum concentrations increased with training frequency after they made their investigation on 14 elite, 11 amateur, and 10 sedentary participants. Therefore, we consider that the differences in findings arise from the intensity and duration of the training, environment conditions of humidity-temperature, the amount of perspiration, the timing of serum blood collection (after training or every two days), the chronic or acute focus of the training, the food preferences of athletes due to regional conditions, the athletes' level of nutrition knowledge, and their economic conditions [27].

The justification that there is no significant difference in chlorine levels in an acute aerobic exercise model is explained by the low level of fluid loss [28]. Another study examining the effect of exercise on serum element level reported that 45 minutes of exercise did not reveal a significant difference in serum chlorine level [26]. On the contrary, when the acute effects of training on element metabolism are considered, several studies reported that HIIT-included swimming training caused a statistically significant decrease in serum chlorine levels between pre-test and post-tests in both males and females [29]. Earlier, it was said that there was no significant difference in chlorine levels between groups in this study. However, when the group averages were examined (experimental Mean=103.0, control Mean=109.0), it was observed that the mean scores of the tennis athletes in the experimental group decreased compared to the control group. Thus, it is likely that HIIT implementations have an impact on chlorine levels. Nevertheless, we think that longer-term applications are needed to confirm the effect of HIIT practices on chlorine levels.

Conclusions

To conclude, training practices remodelled with HIIT applications may influence some element levels, BMI, total body weight, and the resting heart rate of athletes. We can say that HIIT is important in regulating especially the anthropometry of athletes (BMI, total body weight). In addition, the increase in iron levels depending on the HIIT in the experimental group was important. We can say that this can affect both muscle contraction functions and efficiency performance output. Finally, we recommend that HIIT applications should not be done unsupervised due to the decrease of calcium and sodium elements. Athletes' element levels should also be monitored and supported with supplements or nutritional meals in line with expert advice if necessary.

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