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Research Article

Bosuball Exercises and Aerobic Endurance: A Study on Yo-Yo Running Performance of Soccer Referees

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Abstract: The aim of the study was to investigate the effect of 8-week bosuball exercises on Yo-Yo running performance of soccer referees. A total of 40 active soccer referees between the ages of 19-48 participated in the study voluntarily. In the study, Yo-Yo test and maximum oxygen capacity (VO2max) obtained from running distances were used to determine the aerobic capacity of the participants. The normality of the data was tested by Kolmogorov Smirnov test and homogeneity by Levene's test. Paired samples t test was used for pairwise comparisons. Descriptive data were presented as mean and standard deviation. The results of the Pretest were evaluated, and the participants were homogenously divided into control and experimental groups. During 8 weeks, the experimental group performed bosuball exercises in the last 30 minutes of their routine training while the control group continued their routine training. The results of the study showed a significant increase in Yo-Yo running distances and VO2max parameters of the experimental group after the intervention. The change between pre and post aerobic performance test results was not significant in the control group. Bosuball exercises significantly improve aerobic performance of soccer referees. It is recommended to include bosuball exercises in the scientifically based training programs of soccer referees.

Keywords: Aerobic endurance; bosuball exercises; soccer; referee; VO2max.

1. Introduction

Soccer, including combinations of short-term and high-intensity movements (running, sprinting, jumping, etc.) and specific actions (passing, dribbling, goal kicking, assisting, etc.), is considered the most popular sports in the world (Abraham et al., 2022; Devi & Pandey, 2019). Soccer is played on a larger field in terms of the area where it is played among team sports, and aerobic performance during the competition is critical not only for soccer players but also for soccer referees to successfully manage the match (Bogibekov, 2023).

Soccer referees spend approximately 90% of their total energy consumption as aerobic energy (Gomes et al., 2024; Paes et al., 2024) and travelling an average distance of 9 km to 12 km per match (Castillo et al., 2018). They also need to make quick and accurate decisions and manage the match impartially (Samuel et al., 2020) while performing short-term and high-intensity movements such as sudden changes of direction, side and forward sprints (Castillo et al., 2018). Studies in the literature have reported that the percentage of moderate-intensity running for soccer referees is higher than for other activities, in addition, heart rate (HR) measurements during a soccer match showed a maximum mean exercise intensity (HRmax) of approximately 89%, and ~95% of matches exceeded ≥80% of HRmax (Costa et al., 2013; Castillo et al., 2017). This results in high levels of psychological and physiological stress on soccer referees (Parpa &

Michaelides, 2022). The performance of referees in modern soccer depends on strategies to cope with cognitive and physiological demands and the correct interaction of these factors (Tiama et al., 2023). In order to manage this critical process efficiently, referees need to improve their fitness levels and have high aerobic endurance (Baydemir et al., 2021). Aerobic endurance is expressed as the capacity of the heart and lungs to transport oxygen to the muscles, the efficiency of the muscles to use this oxygen, and the capacity of the body to sustain long-term activities using oxygen (Sun et al., 2024). Similarly, accurate assessment of VO_2max through exercise testing protocols such as Bruce protocol has been shown to be a reliable indicator of aerobic fitness in soccer players (Demirhan et al., 2014). To increase aerobic endurance, many different types of exercises are usually applied with high intensity and short duration / low intensity and long duration training (Anhê et al., 2022). These exercises are critical for referees to maximise their performance and alleviate their physiological and psychological loads (Franceschi et al., 2024). In addition, having high aerobic endurance helps soccer referees to concentrate better on the match, to be able to change places quickly in a fast-paced match, and to make more accurate decisions in stressful conditions (Syamsudar & Nurcahya, 2024). Therefore, it is thought that training methods such as bosuball exercises, which involve high-intensity repetitive efforts and show significant effects on aerobic capacity in a short time, should be used in the training of referees (Loh & Chong, 2018). In addition, it has been shown that multicomponent training programs, including agility, are important especially in sports disciplines that require change of direction and movement coordination (Demirhan et al., 2017).

Bosuball exercises contribute to the burning of body fat, improvement of blood circulation, weight control, increase in growth hormone and muscle building by accelerating blood circulation in the body (Saeterbakken et al., 2014). Bosu exercises are also widely used by people who want to do cardio exercises and increase the strength of the muscles in the lower body and core (Sawant et al., 2020). Bosuball exercises significantly increase the heart rate (Bayrakdar et al., 2020). Therefore, these dynamic movements improve aerobic capacity by challenging the cardiovascular and respiratory systems (Turgut et al., 2018). In the literature, bosuball training is mostly focused on balance and strength development (Bouzas-Rico et al., 2022; Kurtoğlu et al., 2024; Zemková et al., 2021; Tura et al., 2024), but studies on its effects on aerobic performance are very limited. It is an important deficiency that there are not enough studies in the literature for soccer where aerobic capacity is so critical in terms of time and distance run. Therefore, the present study is important in terms of filling an important gap in the literature.

In the light of this informations, the aim of this study was to investigate the effect of 8-week bosuball exercises on Yo-Yo running performance of soccer referees. The study hypothesised that bosuball exercises would significantly improve the aerobic performance of soccer referees.

2. Materials and Methods

2.1. Research Group

Forty active soccer referees between the ages of 19-48 years participated in the study voluntarily. G*Power 3.1 software was used to determine the number of subjects to participate in the study and the results showed that it would be appropriate to conduct the study with at least 32 subjects (effect size r: 0.87, lower and upper critical p: 0.55, true power: 0.91). The exclusion criteria were as follows; not having an active refereeing history for the last three years, having a history of lower extremity injury or surgery, any having injury that restricts their participation in physical activity or cardiovascular disease. Participants were included in the study after written informed consent forms were obtained.

2.2. Research Model

This single-blind, randomised controlled study examined the effects of 8 weeks of bosuball exercises on Yo-Yo running performance of soccer referees. During the first visit, anthropometric measurements of the participants were taken and Yo-Yo running test was introduced and detailed information about the study flow was provided. On the following day, Yo-Yo running test was performed with all participants. After the completion of the pre-tests, the participants were randomised into one of two groups with equal proportions (1:1) using computer-approved software (www.random.org) and divided into experimental (n=20) and control (n=20) groups. Participants in the experimental group performed bosuball training in the last 30 minutes of their training 2 days a week for 8 weeks. Meanwhile, the control group continued their routine training. After the 8-week training period, Yo-Yo running test was performed again with all participants for the post-test. All measurements were performed at the same time of day (13.00-15.00) and under similar environmental conditions (temperature ranged from 19 to 22 °C and the humidity from 52 to 60 per cent) on an artificial grass field. From the beginning to the end of the study, the investigators responsible for data collection were blinded to group assignment. In addition, the researcher responsible for the data analysis completed the analyses blind to group assignment on the anonymised data file. Finally, the researchers who applied the training program were not included in the data collection and analysis processes. The primary endpoint of the study was the successful completion of the post-tests following the 8-week training program; the secondary endpoint was the participants' unwillingness to continue the study for various reasons, failure to complete the 8-week training program and the occurrence of any injury limiting physical activity during the relevant period.

2.3. Data Collection

The training sessions were performed according to the program presented in Table 1. The exercises included in the training programs are presented in Figure 1. All exercises were performed in 2 sets with 40 seconds intervals and 20 seconds rest between repetitions.

Figure 1. Bosuball Exercises

Table 1. Bosuball Training Program

Exercise *	1-3 Weeks	3-6 Weeks	6-8 Weeks
(A) Bridge	8 Rep	10 Rep	12 Rep
(B) Single Leg Stance	30 s Each Side	40 s Each Side	12 s Each Side
(C) Mountain Climbers	16 Rep	18 Rep	20 Rep
(D) Lunge	8 Rep For Each L	10 Rep For Each L	12 Rep For Each L
(E) V Squat	10 Rep	12 Rep	14 Rep
(F) Side Squat	8 Rep Each Side	10 Rep Each Side	12 Rep Each Side

** All exercises are 2 sets with 20 seconds rest between each reps and 40s between each sets.*

2.3.1.Anthropometric measurements

The body weight of the participants was measured with an accuracy of 0.1 kg using a body composition analyser (Jawon Body Composition Analyser Model X-Scanplus II, Seoul, Korea). Height was measured with a Stadiometer (Holtain Ltd. Crymych, UK) with an accuracy of 0.1 cm. Both measurements were performed barefoot and in anatomical posture.

2.3.2. Yo-Yo Running Test and Aerobic Power Calculation

The Yo-Yo Intermittent Recovery Test Level 1 is a field test for assessing high-intensity exercise performance with short duration runs (Krustrup et al., 2015). In the test, each participant performed a series of 20-metre shuttle runs at a pace determined by a calibrated audible metronome. There was a standardised rest interval of 5 seconds between shuttles (Bradley et al., 2014). The time given for the shuttles was gradually reduced, while the speed was increased. The test was terminated when subjects failed to reach the start line twice or when the participant felt unable to complete another shuttle at the specified speed (Castagna et al., 2020). The total running distance obtained was recorded in metres and estimated VO2max values were calculated by the following formula (Bangsbo et al., 2008):

$$\text{VO2max (ml/kg/min)} = \text{Yo-Yo IR1 distance (m)} \times 0.0084 + 36.4$$

2.4. Statistical Analysis Methods

SPSS 27.0 package program was used for statistical analysis of the data. Due to the sample size (n=40), normality of the values was tested by Kolmogorov Smirnov test and homogeneity was tested by Levene's test. It was determined that the data had normal and homogeneous distribution. Paired samples t test was used for pairwise comparisons. Descriptive data were presented as mean and standard deviation. In all tests, significance level was accepted as $p<0.05$.

2.5. Ethics Committee Permission

Ethics committee approval was obtained from Giresun University Social Sciences, Science and Engineering Sciences Research Publication Ethics Committee (protocol no: 2025-03/97). Before data collection, participants were thoroughly informed about the study through a detailed presentation and subsequently provided written consent. The research was carried out in accordance with the ethical guidelines of the Declaration of Helsinki.

3. Results

Demographic information of the referees participating in the study is presented in Table 2.

Table 2. Demographic information of the participants

Variables	Mean	SD	Min.	Max.
Age (year)	27.88	6.69	19.00	48.00
Height (cm)	179.43	5.54	166.00	191.00
Weight (kg)	71.08	7.24	54.00	83.00
Training Age (year)	10.18	6.17	5.00	26.00
BMI (kg/m^2)	22.03	1.40	17.04	25.34

SD: standart deviation; Min: minimum; Max: maximum; BMI body mass index

Demographic information, anthropometric measurements and aerobic performance parameters obtained from the pre-test of the control and experimental groups were compared. The results showed that there was no significant difference in all parameters of the control and experimental groups ($p>0.05$) (Table 3).

Table 3. Comparison of the pre-test results of the control and experimental groups

Variables	Experimental Mean ± SD	Control Mean ± SD	t	p
Age (year)	27.90 ± 6.07	27.85 ± 7.42	0.024	0.981
Height (cm)	178.15 ± 6.78	179.95 ± 5.39	-0.931	0.363
Weight (kg)	69.90 ± 7.94	72.25 ± 6.45	-0.982	0.338
BMI (kg/m^2)	21.95 ± 1.18	22.28 ± 1.18	-0.927	0.365
Training Age (year)	10.05 ± 5.88	10.30 ± 6.60	-0.138	0.892
Yo-Yo (m)	1172.00 ± 142.81	1248.00 ± 146.02	-1.358	0.190
VO_{2max} (ml/kg/min)	46.02 ± 1.00	46.55 ± 1.10	-1.310	0.206

SD: standart deviation; BMI: body mass index

Pre and posttest aerobic performance parameters of control and experimental groups were compared. According to the results; pre and posttest Yo-Yo running distance (P=0.000; e.s=.73; change 9.21%) and VO2max parameter (p=0.012; e.s: .99; change 2.47%) of the experimental group differed significantly, but there was no significant difference in the control group ($p>0.05$) (Figure 2).

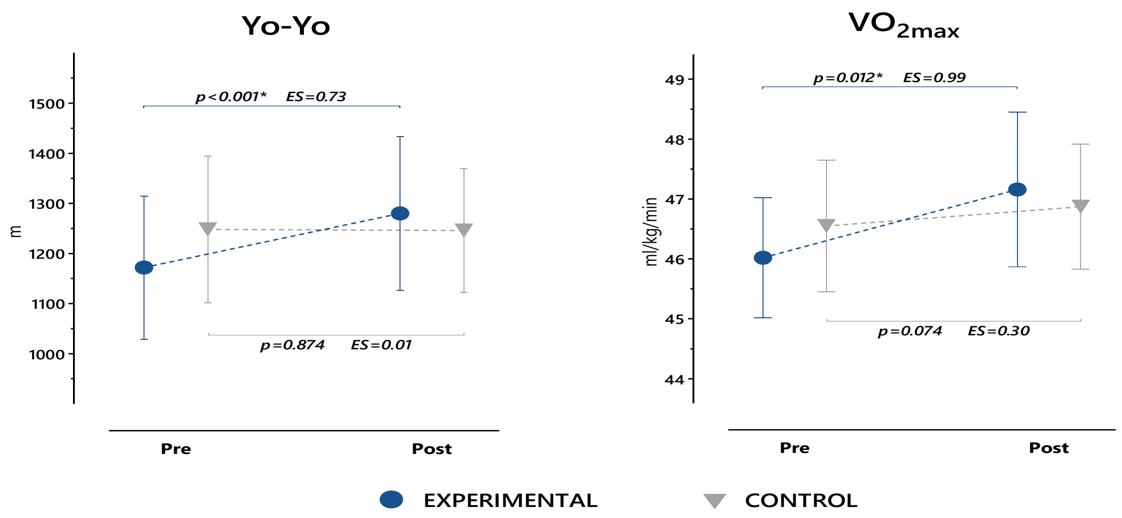

Figure 2. Differences in veriables between control and experimental groups in pre and post test

4. Discussion

This single-blind, randomised controlled study examined the effect of 8 weeks of bosuball exercises on Yo-Yo running performance of soccer referees. The results of the study showed that there was a significant increase in the Yo-Yo test running distances and VO2max parameters of the experimental group in which bosuball exercises were included in the last 30 minutes of their routine training program for two days a week for eight weeks. In the control group, there was no significant difference between the pre-post test results.

The increasing physical performance level of soccer players (Gonaus et al., 2019; Milanovic et al., 2017) causes an increase in internal and external loads not only for themselves but also for the referees during the match (Ai et al., 2020). Some studies have suggested that referees are exposed to physiological stress equal to that of a midfielder (D'Ottavio & Castagna, 2002) and even higher than some players (Castillo et al., 2016; Yanci et al., 2016) during highly competitive competitions. In addition to physiological processes, referees also have decision-making processes that create extra load and stress (Bouzas-Rico et al., 2022). This suggests that it is critical for referees to have good physical fitness and aerobic endurance similar to soccer players. However, the results of the present study showed that the Yo-Yo running distances and VO2max parameters of the participants (Table 2), although all of them were actively refereeing soccer, were considerably lower than some studies in the literature. A study of 45 Spanish referees found that they ran 1591.30 ± 592.43 metres and had a VO2max of 49.77 ± 4.98 ml/kg/min in the Yo-Yo test (Castillo et al., 2016). It can be said that this result may be due to the fact that the participants in the current study are mostly at the beginning of their careers and their physical fitness levels are low. However, the results of the present study showed that the Yo-Yo running distances and VO_2max parameters of the participants (Table 2), although all of them were actively refereeing soccer, were considerably lower than some studies in the literature. A study of 45 Spanish referees found that they ran 1591.30 ± 592.43 metres and had a VO_2max of 49.77 ± 4.98 ml/kg/min in the Yo-Yo test (Castillo et al., 2016). It can be said that this result may be due to the fact that the participants in the current study are mostly at the beginning of their careers and their physical fitness levels are low. A similar trend was observed in a previous study on U-23 national football players from Kyrgyzstan, where VO_2max levels measured in the pre-season period were also found to be relatively low compared to international standards (Demirhan et al., 2019).

On the other hand, Federation Internationale de Football Association (FIFA), Union of European Football Associations (UEFA) and national federations systematically evaluate the physical fitness levels of referees within their organisations and monitor their training programs (Weston et al., 2012). Of course, it is thought that the development of referees with scientific-based training methods will make a significant contribution to the development of soccer. Bosuball training is one of these methods, and it is recognised to have outstanding performance in a short time due to high-intensity exercises (Prasetyo et al. 2023). In the present study, in order to investigate the effect of bosuball exercises on the aerobic endurance of referees, the participants were divided into two groups as control and experimental. Comparison analysis showed that these groups were homogeneous (Table 3). This demonstrated that the effects of bosuball exercises applied to the experimental group in the study could be objectively evaluated.

When the pre-post test results obtained in the study were compared, it was shown that there was a significant increase in the running distance and VO2max values of the experimental group, but a similar increase was not observed in the control group (Figure 2). This result suggested that bosuball exercises improved core muscles, efficiency of the neuromuscular system and running mechanics. This was confirmed by the increase in running distances of the experimental group. This result is similar to many studies in the literature (Demir, 2019; Kalra et al., 2021; Prasetyo et al. 2023). Turgut et al. (2018) found that bosuball exercises applied to 60 sedentary individuals reduced the percentage of fat around the waist and hips and increased lean muscle mass. A similar study on swimmers suggested that bosuball exercises had significant improvements in the physical fitness parameters of subjects (Nasr, 2023). The results of this study explain and support the significant improvement of running distances in the present study.

VO2max represents the maximum amount of oxygen that the organism can use during an exercise and is one of the important determinants of cardiorespiratory fitness level (Smirmaul et al., 2013). One of the most important methods used to improve VO2max is high-intensity interval training (Castillo et al., 2017). In this exercise method, which was also used in the current study, short-term high-intensity exercise loads are followed by recovery periods of low intensity or passive rest (Oliveira-Nunes et al., 2021). These exercises increase the number and function of mitochondria in skeletal muscles, improve the oxygen utilisation capacity of muscle cells and therefore increase the VO2max of the organism. Furthermore, intermittent high-intensity exercise increases maximum oxygen capacity through not only central (cardiovascular system) but also peripheral (muscle tissue) adaptations (O'Reilly & Wong 2012). Festiawan et al (2021) suggested that high-intensity interval training caused a 40% increase in VO2max. Similarly, in a study conducted on men and women, it was found that high-intensity interval training provided a significant increase in VO2max (Astorino et al., 2017). Therefore, it can be said that the intermittent and high-intensity character of bosuball exercises affected the increase in VO2max levels of the experimental group in our study.

Although the results of the current research provide important contributions to the literature, it has some limitations. The important limitations of the study are that the measurements applied to the participants were not clinical applications and the estimated calculation of VO2max values. In addition, external factors such as dietary habits, psychological status and sleep patterns of the participants in their daily lives could not be controlled. These individual factors have the potential to influence participants' VO2max levels and thus their aerobic capacity. Finally, although the bosuball exercises applied to the experimental group seem to contribute to their aerobic capacity, further research is needed to understand exactly how they affect the aerobic demands specific to soccer refereeing in the competition environment.

5. Conclusions

In the study, the effect of bosuball exercises on Yo-Yo running performance and VO2max levels of soccer referees was examined and significant increases were observed in both parameters. The findings showed that the intervention had a complex effect on the cardiovascular capacity of the soccer referees and improved their fitness levels. The results revealed that bosuball exercises would be an effective method to improve the on-field performance of soccer referees. In future studies, increasing the sample group and long-term follow-up of the training processes will increase the generalizability of the results. It is recommended that bosuball exercises be added to the scientifically based training of soccer referees to increase their aerobic capacity.

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