Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fìzičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

Original scientific article

Physiological Response to Speed Endurance Soccer Training in Amateur Players

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

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Accepted for Publication: September 9, 2024
Published: October 30, 2024

DOI: 10.17309/tmfv.2024.5.04

Abstract

Objectives. This study aimed to examine the physiological response to speed endurance soccer training (SEST), which involved the measurement of heart rate (HR), blood lactate (LAC), and blood pressure (BP) are measured during the four-week intervention period.

Materials and methods. The one-group pretest-posttest pre-experimental design was used in this study. The study comprised 15 male amateur soccer players with an average age of 16.13 ± 0.52 years. The participants' mean height was 167.4 ± 4.63 cm, weight was 57.69 ± 12.11 kg, and BMI was 20.44 ± 3.45 kg/m^2. The data findings are presented using the mean and standard deviation. The paired t-test was employed to assess the impact of each group. The threshold for statistical significance was set at a p-value of less than 0.05. The effect size (ES) was calculated using Cohen's ES as a metric to quantify the magnitude of the difference between the pretest and posttest stages.

Results. The HR results monitoring during the intervention period were in the high-intensity zone, with an average of 91.67 ± 0.6 % and a HR of 187.67 ± 1.24 bpm. No significant change was observed in the heart rate response from baseline to end of intervention. The LAC results showed that the lactate level was in the high category, namely an average of 11.03 ± 1.3 mmol·L^{-1}. BP indicated a significant difference between pretest and posttest ($p \leq 0.05$). The systolic blood pressure (SBP) demonstrated an increase of Δ % = 0.95, while the diastolic blood pressure (DBP) showed an increase of Δ % = 1.39.

Conclusions. The findings of this study indicate that SEST has a notable effect on the body's physiological functions, namely on the cardiovascular system, anaerobic metabolism, and blood pressure. This effect was observed over a period of four weeks in amateur soccer players.

Keywords: blood lactate, blood pressure, heart rate, speed endurance soccer training.

Introduction

The progress of soccer places a greater demand on players, especially in their capacity to handle the escalating intensity of matches, both with and without possession of the ball (Barnes et al., 2014; Bush et al., 2015; Nassis et al., 2020). Consistent with prior studies, it has been determined that soccer is a sport that requires high levels of physical exertion. The average heart rate during a soccer game reaches 85 % of the maximum heart rate, and it is possible to attain an intensity of 90-95 % of the maximum heart rate (Mendez-Villanueva et al., 2013; Rebelo et al., 2014). To meet the high physical demands in soccer, physical training alone is insufficient; a combination with tactical training is also necessary (Kusuma, Kusnanik, Lumintuarso, & Phanpheng, 2024). Recent research has identified a holistic training method known as Speed Endurance Soccer Training (SEST), which has been proven to enhance the abilities of soccer players (Kusuma, Kusnanik, Lumintuarso, Setijono, et al., 2024). However, this research has limitations, particularly the lack of an in-depth study on physiological responses, such as heart rate (HR), blood lactate, and blood pressure. Understanding physiological responses is crucial to ensure that the training aligns with its objectives (Clemente et al., 2023; Dello Iacono et al., 2022; Lechner et al., 2023). These indicators are vital in determining whether the training goals are met, as they provide insight into the internal load and the body's adaptation to training. Therefore, further studies that integrate physiological aspects into the evaluation of the SEST program are essential to ensure its effectiveness and appropriateness for soccer players.

Previous research on physiological responses has been carried out but is still separated into two studies, namely HIIT and SSG (Arslan et al., 2017; Köklü & Alemdaroğlu, 2016; Kunz et al., 2019; Ouertatani et al., 2022; Radziminski et al., 2013). Studies analyzing physiological responses to the combined training concept of HIIT and SSG are still very limited. Previous research has analyzed heart rate and blood lactate responses to SSG training combined with running training, but this study did not analyze blood pressure variables (Köklü et al., 2020). Physiological responses that can be monitored from the exercise process are blood lactate (LAC), heart rate (HR), and systolic and diastolic blood pressures (SBP and DBP) (D. M. Forte et al., 2022; Köklü et al., 2017). By knowing the lactate level in the blood, you will know the type of exercise a person is doing at an aerobic or anaerobic level and a person's physical fitness (Selmi et al., 2021). Meanwhile, measuring blood pressure during exercise can provide information about the cardiovascular response to physical activity (Arboleda-Serna et al., 2016).

Many coach, both professional and amateur, have included the SEST training idea into their programs, even if they do not openly refer to it by name. This approach incorporates both physical and tactical elements under a single training model. SEST involves various acts in soccer, including passing, dribbling, crossing, shooting, sprinting, as well as situations such as attacking, transitioning, and defending. In order to enhance physical performance, it is important to examine an individual's physiological reaction throughout the execution of this exercise. To investigate the physiological response of LAC, HR, SBP and DBP during SEST training, it is imperative to do study on this topic. It is anticipated that it can offer more reliable information in the realm of sports coaching, particularly for soccer coaches, whether they are professionals or amateurs.

Materials and Methods

Study participants

The population for this study consisted of 117 male soccer player. This study included a sample of 15 male soccer players with an average age of 16.13 ± 0.52 years. The participants had an average height of 167.4 ± 4.63 cm, weight of 57.69 ± 12.11 kg, and BMI of 20.44 ± 3.45 kg/m^2.

Study Organization

The research employed a pre-experimental procedure utilizing a one-group pretest and posttest design. Subjects were given a pretest to determine their initial HR, LAC, and BP. Next, the subject was given SEST for four weeks with a frequency of three times a week, and intensity 80-90 % HRmax. After treatment, the samples were given a posttest in the final week to determine differences in physiological responses to SEST. Apart from that, each sample training session continues to have its HR and BP monitored, while its LAC was monitored once a week. The process of gathering data involved the use of an OMRON automatic equipment (OMRON Model HEM-7130 L, Omron Co., Osaka, Japan) to measure BP. HR measurement utilizing the Polar H10 Sensor, manufactured by Polar Inc. in the United States. Concurrently, LAC levels were assessed using the Accutrend Plus Meter (Accutrend® lactate meter, Roche Diagnostics, Mannheim, Germany).

Statistical Analysis

The data is displayed in the form of the mean and standard deviation. The Shapiro-Wilk test was employed to evaluate the normality of the data. The percentage change (Δ%) between the pretest and posttest results during the training period was determined using the formula: $\Delta\% = ((\text{Post-Pre})/\text{Pre})*100$. A paired t-test was performed to assess the effect within each group. The threshold for statistical significance was established at a p-value of less than 0.05. Cohen's effect sizes (ES) were calculated to measure the extent of disparities between groups. A value of ES more than 0.8 was categorized as big, while a value between 0.8 and 0.5 was classified as medium. A value between 0.5 and 0.2 was considered minor, and any value below 0.2 was regarded as negligible, according to Cohen (2013).

Results

The normality test using the Shapiro-Wilk test shows that the data was normally distributed with a significance value of Sig > 0.05. Next, a paired sample t-test was carried out with the results in Table 1.

Table 1. Pretest and posttest results of SEST

Parameter	Pretest	Posttest	Δ %	p	ES
Heart Rate (bpm)	185.64 ± 6.59	186.80 ± 5.16	0.62	0.600	0.140
Heart Rate (%)	90.67 ± 3.14	91.24 ± 2.51	0.62	0.600	0.140
Lactate (mmol/L)	10.33 ± 2.31	9.87 ± 0.98	4.45	0.410	0.220
SBP (mmHg)	119.33 ± 2.97	118.20 ± 3.00	0.95	0.000*	2.190
DBP (mmHg)	76.80 ± 2.62	75.73 ± 2.46	1.39	0.000*	1.110

Description: Data are presented as mean ± SD; Δ (%): Percentage of change between pre and post-training performance; p: Level of significance; ES: Effect size; (*): Significant at pretest (p < 0.05).

Based on the research results Table 1 shows the pretest and posttest analysis data where the SBP and DBP values have a significant difference with $p < 0.05$, with an increase of 0.96 % in SBP and 1.39 % in DBP. Meanwhile, other parameters did not show significant differences.

Figure 1 above shows that the results of HR monitoring on SEST are in the high category where, in each training session, the average heart rate is above 90%, whereas if we look at the average for 4 weeks of training, the heart rate shows an average of 91.67 ± 0.6 %.

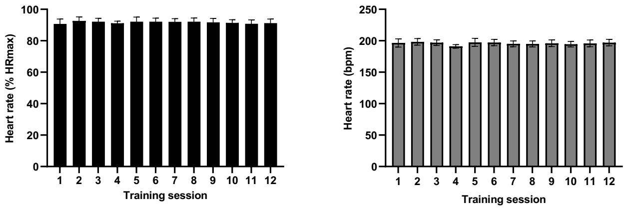

Fig. 1. HR monitoring during four weeks of SEST

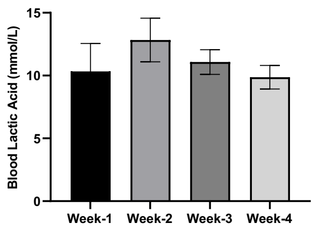

Fig. 2. LAC monitoring during four weeks of SEST

Fig. 2 above shows LAC monitoring during the four weeks of SEST. If we look at the LAC results per week, it shows that lactate was 10.33 ± 2.23 mmol/L in the first week, 12.83 ± 1.74 mmol/L in the second week, 11.08 ± 0.98 mmol/L in the third week, and 9.87 ± 0.94 mmol/L in the fourth week. Meanwhile, if we look at the total of four weeks of SEST sessions, the average LAC result was 11.03 ± 1.3 mmol/L.

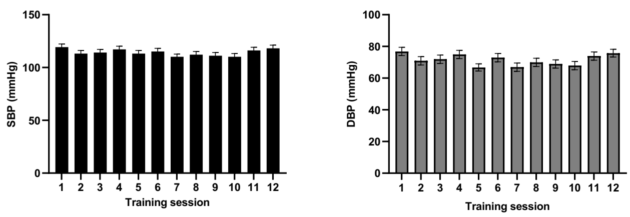

Fig. 3. BP Monitoring for four-weeks

Fig. 3 above shows the BP monitoring results for each training session for four weeks. The average SBP and DBP results for each exercise show the normal limits below 120 mmHg and 80 mmHg. If we look at the average for four weeks, it was that SBP: 114.21 ± 3.07 mmHg and DBP: 71.47 ± 3.46 mmHg.

Discussion

This study analyzes the physiological response to SEST during 4 weeks of treatment. The findings showed that the HR response during exercise entered the high-intensity zone with an average of 91.67 ± 0.6% and a heart rate of 187.67 ± 1.24 beats/min. There was no significant change in heart rate response from the start of treatment to the end. The response from lactate taken 4 times showed that the lactate level was in the high category, namely an average of 11.03 ± 1.3 mmol·L^{-1}. An interesting finding was an increase in the first 2 weeks and a relative decrease in the final 2 weeks, while blood pressure showed a significant difference between the pretest and posttest. SBP shows an increase of Δ% = 0.95, while DBP shows an increase of Δ % = 1.39.

Significant findings related to physiological responses, especially in HR levels during four weeks of SEST. Over four weeks, it was observed that the training zone was consistently in the high zone for each training session. These results align with previous research, which examined the response of SSG combined with running drill to produce a heart rate of 88.9 ± 2.5 % HRmax in the 3-a-sided model and 86.8 ± 4.0 % HRmax in the 4-a-sided (Köklü et al., 2020). Previous research also obtained similar results, namely that the HR level was in the high category (Brandes & Elvers, 2017; Halouani et al., 2017). The increase in HR occurs simultaneously with a decrease in parasympathetic stimulus and an increase in autonomic sympathetic stimulus, which during exercise is caused by proprioceptors (movement), baroreceptor reflexes (carotid dilation), and chemoreceptors (low pO_2, high pCO_2, and H+ in the bloodstream) (O'Leary, 1996). These findings indicate that SEST training consistently induces high levels of cardiovascular activity, with exercise participants' HR falling into the high category. This phenomenon can be interpreted as a physiological response that occurs due to the high intensity of the exercise. The sustained increase in HR over four weeks indicates that the exercise participants continued to experience significant cardiovascular stress, resulting in cardiac adaptation to the continuous training load. These findings provide a further understanding of the effects of SEST training on the cardiovascular system, and the implications can be used by trainers to design appropriate training programs to increase endurance (Brandes & Elvers, 2017).

This study highlights interesting findings related to physiological responses, specifically to LAC levels. In the first two weeks of SEST, a significant increase in LAC levels after the training session was found to be 12.83 ± 1.74 mmol·L^{-1}. These results are in line with previous research which examined the response of combined SSG with a running drill, which produced LAC 9.6 ± 1.9 mmol·L^{-1} in the 3-a-sided model and 8.2 ± 1.7 9 mmol·L^{-1} in 4-a-sided (Köklü et al., 2020). Previous research also obtained similar results, namely high Lactad levels (Chmura et al., 2023). Elevated lactate concentrations are believed to result from glycolytic flow rates (Gladden et al., 1995; MacRae et al., 1992). This indicates that the exercise participants experienced an increase in anaerobic metabolic rate, reflecting the high intensity of the exercise. An interesting finding in the last two weeks of the study was a tendency to decrease LAC levels after the SEST training session. Even though there was a decrease, the lactate results in the third and fourth weeks were 9.87 ± 0.94 mmol·L^{-1}. This value was still in the high category, which exceeded the lactate threshold of the lactate curve according to the Stegmann procedure (Faude et al., 2013, 2014). The decrease in lactate can be interpreted as the working of the Cori cycle in the liver. The Cori cycle refers to the metabolic pathway of lactate produced by anaerobic glycolysis in muscle cells, which is transferred to the liver and converted into glucose for eventual return to the muscles (Yang et al., 2020). Additionally, the decrease may reflect the body's adaptation to sustained exercise, where the exercise participant becomes more efficient in his metabolic processes. A decrease in LAC levels does not significantly reflect a decrease in exercise intensity or reduced physiological impact but rather indicates the body's ability to adapt to high-intensity exercise over time (Hostrup & Bangsbo, 2023).

In the Panveloski-Costa et al. (2012), the decrease in blood lactate concentration after 6 weeks of exercise was based on the effectiveness of muscle performance in storing

PCr. An increase in muscle ability to resynthesize PCr is possible because training during the first 2 weeks increases muscle function (volume and number of muscle fibers) so that a lot of PCr is stored in it after 2 weeks of training. Forbes' study also found increased PCr resthesis in thigh muscles, which also carried out high-intensity exercise for 2 weeks (Forbes et al., 2009).

The pretest and posttest results showed that SBP and DBP had significant differences. However, if seen from monitoring each exercise, there were variations in increasing and decreasing blood pressure. This study's findings align with previous research with positive results in reducing blood pressure (Carpes et al., 2022; Costa et al., 2018). However, the sample in the study was people who had hypertension. Other studies have found decreased DBP due to HIIT training (Leal et al., 2020; Way et al., 2019). Other research proves a decrease in SBP in HIIT training (Oliveira et al., 2023). Different findings from the previous study that compared the BP response in the HIIT and MICT exercise models, which resulted in a reduction in diastolic blood pressure only in the MICT model (Arboleda-Serna et al., 2019). This indicates that SEST training may have varying effects on exercise participants' blood pressure over time. These fluctuations can reflect individual responses to training intensity and the body's adaptation to changing workloads. These findings provide important insight that BP responses in the context of SEST exercise may vary, and understanding these dynamics may be an important factor in designing effective and safe exercise programs.

Conclusions

SEST produces significant physiological impacts with dynamic cardiovascular system responses, anaerobic metabolism, and blood pressure over a four-week training period. This understanding can be the basis for designing exercise programs that suit the physiological responses of exercise participants

Conflict of interest

No conflict of interest was reported by the authors.

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Фізіологічна реакція організму гравців-аматорів на тренування швидкісної витривалості у футболі

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 1 табл., 3 рис., 41 джерел.

Мета дослідження. Мета цього дослідження полягала у вивченні фізіологічної реакції на тренування швидкісної витривалості у футболі (ТШВФ), що передбачало вимірювання показників частоти серцевих скорочень (ЧСС), рівня лактату в крові (ЛАК) та артеріального тиску (АТ) протягом чотиритижневого періоду інтервенції.

Матеріали та методи. У цьому дослідженні використовувався одногруповий передтестовий та післятестовий передекспериментальний метод. У дослідженні взяли участь 15 футболістів-аматорів чоловічої статі із середнім віком 16,13 ± 0,52 року. Середній зріст учасників становив 167,4 ± 4,63 см, вага — 57,69 ± 12,11 кг, а ІМТ — 20,44 ± 3,45 кг/м2. Результати дослідження представлено із застосуванням середнього значення та стандартного відхилення. З метою оцінки ефективності впливу дослідження кожної групи використовувався парний t-критерій. Поріг статистичної значущості був встановлений на рівні p-значення менше 0,05. Розмір ефекту (ES) розраховували з використанням ES Коена як показника для кількісної оцінки величини різниці між перед- та післятестовим етапами.

Результати. Результати вимірювання показників ЧСС під час періоду інтервенції знаходилися в межах зони високого рівня інтенсивності, в середньому 91,67 ± 0,6 %, а ЧСС становила 187,67 ± 1,24 уд/хв. Значних змін у реакції ЧСС від початку до завершення інтервенції не спостерігалося. За результатами аналізу ЛАК, показник лактату в крові був у межах високого рівня, а саме становив у середньому 11,03 ± 1,3 ммоль·л-1. Рівень АТ вказував на достовірну різницю між результатами до та після проведення тесту ($p \leq 0,05$). Систолічний артеріальний тиск (САТ) збільшився на Δ % = 0,95, тоді як діастолічний артеріальний тиск (ДАТ) підвищився на Δ % = 1,39.

Висновки. Результати цього дослідження свідчать про значний вплив ТШВФ на фізіологічні функції організму, а саме на серцево-судинну систему, анаеробний метаболізм та артеріальний тиск. Даний ефект спостерігався впродовж чотиритижневого періоду у футболістів-аматорів.

Ключові слова: лактат крові, артеріальний тиск, частота серцевих скорочень, тренування швидкісної витривалості у футболі.

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Cite this article as: Kusuma, I. D. M. A. W., Kusnanik, N. W., Pramono, B. A., Pranoto, A., Phanpheng, Y., Nurpratiwi, R., Bawono, M. N., & Nurhayati, F. (2024). Physiological Response to Speed Endurance Soccer Training in Amateur Players. *Physical Education Theory and Methodology, 24*(5), 704-710. https://doi.org/10.17309/tmfv.2024.5.04

Received: 26.07.2024. Accepted: 09.09.2024. Published: 30.10.2024