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Effect of 6 weeks of short intermittent running training versus small-sided games on heart rate variability, aerobic and anaerobic performance in Indian elite soccer players

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Abstract*---Background:*** Soccer is characterized by long periods of low to moderate intensity activity interspersed with periods of high-intensity actions, such as single and repeated sprints. Therefore, a well-prepared soccer player must be able to endure long periods of low- to moderate intensity activity and sustain periods of explosive match effort intensification. *Objective*: To evaluate the effects of 6-weeks short interval running training and Small Sided Games on Heart Rate Variability measurements, aerobic capacity and performance in well trained Indian elite soccer players. *Methods*: A pretest – posttest experimental design was used in our study. 90 elite male soccer players was assigned into three groups by computer generated block randomization. Group I- Short Interval running Training (N-30), Group II- Small sided game Training (N-30) and Group III- Generic Training (control group, N-30). Autonomic control by HRV, vertical jump height, agility, 10m-30m sprint performance and $VO2_{max}$ by multistage fitness test was analysed. *Result*: Pre-intervention and post- intervention results was analysed and compared. The difference in agility, vertical jump height, 10m sprint time and $VO2_{max}$ was more in the SIRT group as compared the SSG and Generic (control) group. This difference was statistically significant ($p<0.001$). Comparing the three groups, a significant increase in RMSSD was seen in SIRT group (increase by 39.87±22.95) as compared to the SSG group (decrease by 8.28±9.24) and Generic

(Control) group (decrease by 44.23±24.06) which saw a decrease. This change was significant. ($p<0.001$). *Conclusion:* In conclusion, the results of the present study suggest improvements promoted by intensive training phase in elite soccer players, especially in HRV which shows parasympathetic adaptation.

***Keywords*---**Agility, vertical jump height, soccer players, Heart Rate Variability, VO2max.

Introduction

Soccer is characterized by long periods of low to moderate intensity activity interspersed with periods of high-intensity actions, such as single and repeated sprints. Additionally, explosive actions, such as accelerations, decelerations, quick changes of direction, and jumps, often occur in key moments of the match (e.g., scoring situations). Therefore, a well-prepared soccer player must be able to endure long periods of low- to moderate intensity activity (i.e., endurance performance) and sustain periods of explosive match effort intensification(Clemente et al. 2021).This varying intensity (from low to high), as well as matches lasting as long as 90 min (depending on age), involves on average > 80% of peak heart rate and approximately 75% of maximal oxygen uptake in youth soccer players, imposing considerable demands on both aerobic and anaerobic energy production (i.e., in connection with short sprints, jumps, tackles) (Kunz et al. 2019).

In order to improve endurance as well as single and repeated explosive performance among soccer players, a time efficient method (i.e., compared to conventional continuous running) generically known as high-intensity interval training (HIIT) has been proposed(Faude et al. 2013). High-volume or continuous low-intensity training has been employed successfully to improve certain aspects of endurance performance, such as peak oxygen uptake (VO2peak), individual anaerobic threshold, and/or maximal velocity in youth soccer players(Laursen and Jenkins 2002). HIIT, characterized by periods of intense exercise at > 90% of peak heart rate (HRpeak) alternating with periods of low-intensity activity, and SSG, a soccer-specific form of HIIT, show great potential to improve certain aspects of the endurance of youth soccer players. Both of these types of training improve key variables related to success in soccer, e.g., VO2peak and maximal running performance (i.e., shuttle run testing and time-trials), as well as performance in connection with soccer specific tests (i.e., total distance covered, number of sprints, and number of contacts with the ball) in a time-efficient manner(Arazi et al. 2017)(Arcos et al. 2015). The lengths of training periods and intervals of rest, number of intervals and sessions of HIIT or SSG per week, and the number of players and size of the pitch can be varied in virtually an endless number of ways(Arcos et al. 2015)(Faude et al. 2014)(Cofano, Raiola, and Colella 2020).

From a practical point of view, questions arise among coaches concerning (1) the overall responses of youth soccer players to HIIT in comparison to other endurance protocols with respect to endurance and other important determinants

of performance, such as the ability to sprint and jump; and (2) whether SSG, a sport-specific form of HIIT, results in improvement of these same parameters comparable to those achieved with running-based HIIT(Prajapat et al. 2016)(Harper, Carling, and Kiely 2019).

Heart rate variability (HRV) has been extensively used as a non-invasive and time-saving tool to monitor training status and physiological adaptations both in moderately trained individuals and in athletes(Dong 2016). In fact, studies show that improvement in aerobic endurance is positively related to baseline HRV and changes in HRV in response to training. Furthermore, vagally mediated HRV indices can be effectively implemented to guide training load prescription. For instance, a training program tailored by daily measures of HRV provided superior performance improvements than traditional periodized training in endurance athletes. More specifically, in the individualized training program, the athletes performed only high-intensity training sessions during periods in which cardiac vagal activity was within the individual's "normal values" (as established by 7-day HRV moving averages, with the smallest worthwhile change [SWC] calculated as 0.5 3 SD)(Dellal et al. 2015). In addition, it is important to note that athletes with higher vagally mediated HRV and cardio-respiratory fitness levels are better able to cope with a given training load, demonstrating lower weekly HRV fluctuations (as quantified by the weekly coefficient of variation [CV]). These findings led researchers to advocate the importance of maintaining high levels of cardiac parasympathetic activity in athletes to optimize training-related adaptations. This is especially true when considering the dramatically low values of HRV found in overtrained athletes(Inoue et al. 2016).

Efficient training provides sufficient exercise stimuli to enhance athletes' performance capacities while avoiding sustained non-functional overreaching or under recovery. Continuous athlete monitoring may provide information that can be used to balance stress and recovery, ultimately increasing the performance readiness of the athlete and minimizing the risk of illness and injury(Impellizzeri, Marcora, and Castagna 2006)(Siegler 2003). A variety of tools, such as psychometric questionnaires, blood-borne markers, heart rate (HR)-based measures, and (sub-maximal or non-fatiguing) performance tests, have been discussed for their potential as surrogate markers for assessing fatigue, recovery, or performance. Ideally, so that they can be used frequently in sports practice, these measures are non-fatiguing, easy to administer, inexpensive, and sensitive to performance changes and can provide immediate feedback. The research question is whether 6-weeks short interval running training and SSG will impart its effectiveness in the desired parameters on HRV measurements, aerobic capacity and performance in well trained Indian elite soccer players. The experimental hypothesis is there will be significant improvement on HRV measurements, aerobic capacity and performance in well trained Indian elite soccer players after 6-weeks of short interval running training and SSG. The aim of the study is to determine the effects of 6-weeks short interval running training and SSG on HRV measurements, aerobic capacity and performance in well trained Indian elite soccer players. The objective of this study is to evaluate the effects of 6-weeks short interval running training and SSG on HRV measurements, aerobic capacity and performance in well trained Indian elite soccer players. The significance of this study is to inculcating 6-weeks short

interval running training and SSG will enhance HRV, physiological adaptations and aerobic capacity thereby improving performance.

Methodology

A pretest – posttest experimental design was used in our study. Pre- intervention and post- intervention results was analysed and compared. 90 elite male soccer players was taken from JLN Stadium, Tyagraj stadium, Village soccer and Chartrasal stadium, Delhi, India. Subjects was assigned into three groups by computer generated block randomization. **Group I-** Short Interval running Training (30), **Group II-** Small sided game Training (30) and **Group III-** Generic Training (control group, 30). Independent Variables of this study is Short Interval running Training (SIRT) and Small- sided game Training (SSG). The dependent variables of the study are Autonomic control by HRV [RMSSD, LF, HF, LH/HF ratio], Jump performance by Vertical Jump Height, Sprint performance by 10m and 30m sprint, Repeated sprint ability (RSA) and Maximal Oxygen Uptake($VO_{2\ max}$) by multistage fitness test. The Inclusion Criteria is Elite young soccer player aged 12-30yrs males and subjects within normal body mass index: 18- 24 kg/m^2. The Exclusion Criteria is any known medical history including history of unstable angina, recent cardiac infarction, uncompensated heart failure, severe valvular illness, pulmonary disease, uncontrolled hypertension, kidney failure, autonomic dysfunction, diabetes, any musculoskeletal disorders, psychic disorder and drug users specially drug affecting nervous system or any history of alcohol consumption or smoking, tobacco intake, caffeine addict.

Participants and methods

Before the commencement of data collection, subjects have explained the purpose, methodology, and possible risks of the study. Subject and parental written informed consent were obtained. A RCT study was performed on 114 male soccer players (age: 16.8 ± 3.11; height: 167.85 ± 8.27; weight: 57.05 ± 10.66; BMI: 20.16 ± 3.02). . To take part in the study, the players be involved in the sport for at least 2 years, be free from any injury at the time of testing. The assessments were divided into 2 sessions: an introductory session and a formal assessment. After a detailed general history of symptoms, an introductory session was performed to assess anthropometric profile, body composition analysis and practice trial of 20-meter shuttle run test. The assessments were scheduled in the morning hours between 7-11 am. Vitals (heart rate, blood pressure, spo2, and temperature) of the subjects were measured before the commencement of the assessment. Heart rate variability (HRV) was measured under controlled circumstances. Subjects were pre informed about not eating or drinking caffeinated beverages at least two hours before the testing and to avoid any physical activity to prevent alteration in the heart rate.

Protocols of the HIIT Interventions
Short-Duration Intermittent Running (SIRT)

All subjects completed all the short duration intermittent running sessions presented in Table 1. During these sessions, running distances were individualized based on the subject's measured MAS. In case of active recovery,

players had to jog at 9 km.h-1 (with corresponding distance). Each exercise protocol was performed in different weeks and on a natural grass field.

Table 1- Short Duration Intermittent Running Characteristics					
Intermittent training (working time-recovery time) (s)	Work Intensity	No. X duration of series	Intraseries recovery	Interseries recovery (min)	Total duration of session (min)
30-30 PR	100% VO2 max	2X10 min	Passive	10 (passive)	30
30-30 AR	100% VO2 max	2X10 min	Active	10 (passive)	30
15-15	100% VO2 max	2X10 min	Passive	8 (passive)	28
10-10	110% VO2 max	2X7 min	Passive	6 (passive)	20
5-20	120% VO2 max	1X7 min, 5s	Passive	-	7
PR= passive recovery; VO2max=lowest velocity associated with maximum oxygen consumption or maximum aerobic speed; AR= active recovery (the soccer player had to jog at 9 km/hr)					

Small-Sided Games (SSG)

All subjects performed all the different sided games presented in Table 2. The different sided games were performed with or without a goalkeeper in smaller areas on a natural grass field. With goalkeepers, the sided games consisted of playing a match, whereas without goalkeepers, the sided games consisted of keeping the ball despite the opponents' efforts to take the ball. Several balls were placed all around the area of the sided games for immediate availability in order to avoid stopping the game.

Table 2- Characteristics of Small- Sided Games					
Sided game	No. of Goalkeepers	Game Area (m)	No. X duration of series	Interseries recovery (min)	Total duration of session (min)
1 vs 1	0	10 X10	4 X 1 min, 30s	1 min, 30 s (passive)	10 min, 30 s
2 vs 2	0	20 X 20	6 X 2 min, 30s	2 min, 30 s (passive)	27 min, 30 s
4 vs 4 GK	2	30 X 25	2 X 4 min	3 min (passive)	11 min
8 vs 8 GK	2	60 X 45	2 X 10 min	5 min (passive)	25 min
8 vs 8	0	60 X 45	4 X 4 min	3 min (passive)	25 min
10 vs 10 GK	2	90 X 45	3 X 20 min	5 min (passive)	70 min
Total duration of the session = the end of this duration corresponded to the end of the last series of the reduced game; GK= presence of goalkeepers					

Experimental set-up							
Monday	Tuesday	Wednesday	WEEK 1	Thursday	Friday	Saturday	Sunday
	2 vs 2	10-10s at 110% VO2		rest		Official Game	

		max	WEEK 2				
	30-30s at 100% VO2 max AR	10 vs 10 GK	WEEK 3	rest			Official Game
		30-30s at 100% VO2 max PR	WEEK 4	rest		Official Game	
		1 vs 1	WEEK 5	rest	8 vs 8 GK	Official Game	
	8 vs 8		WEEK 6	rest	5-20s at 120% VO2 max	Official Game	
15-15s at 100% VO2 max		4 vs 4 GK		rest		Official Game	
VO2 max= lowest velocity associated with maximum oxygen consumption or maximum aerobic speed; x versus y= sided games with x against players; GK= presence of goalkeepers; PR= passive recovery; AR= active recovery (the soccer players had to jog at 9km.hr^{-1}).							

Formal assessment

The formal assessment was performed within one week of the introductory session. The players were tested in groups of 4-5 at one time. On the day of formal assessment, practice trial of 20-meter shuttle run test was performed. The participants were told to perform a routine warm-up before performing the tests to prevent injury. And, an appropriate recovery time had been given in between the tests to avoid fatigue.

Heart Rate Variability analysis

The HRV measurement were performed using a Heartwear Shimmer ECG device by EsMedTek, Consensys software for recording and sinusCor for the analysis of the HRV. The procedure followed the recommendations of the Task Force. The HRV was recorded in resting state in sitting position. All the subjects were instructed to maintain calm and normal breathing pattern and temperature of the room was maintained. To maintain the quality of the HRV recording and to minimise the likelihood of signals interference from electrodes falling off or sporadic contact caused by hairs or dirt particles, it was ensured that all the participants shaved off their chest hair for good electrode to skin contact. Also, the skin was cleaned to remove oils and sweat so that interferences of the signals can be avoided. The 5 electrodes were taken in which the two electrodes were placed at 2cm below the clavicle (midclavicular line) on the right and left side. Rest two electrodes were placed two finger breadths above the ASIS on the right and left side. The remaining one electrode was placed over the 4-5th intercostal space. The machine was simultaneously connected to Consensys software via Bluetooth in laptop and HRV was recorded. First 2 minutes of ECG was recorded to lookup for observation and then actual ECG was recorded for 5 minutes. While the participants were seated, parameters of HRV analysed were mean RR intervals

(RMSSD), standard deviation of NN interval (SDNN), low frequency spectral (LF) component; high frequency spectral component (HF); low frequency/high frequency (LF/HF).

Vo2max/aerobic fitness

20-meter shuttle run test (20msrt): the 20-MSRT is widely used for cardiovascular assessment, also known as the "multistage fitness test" or pacer test. Equation suggested by leger et.al 1984, 1988 is used for calculation of VO2max. The 20-MSRT consisted of one-minute stages, paced by beeps from the audiotape. 20-msrt is continuous, incremental speed-running. According to the original protocol, the athletes started at a speed of 8.5 km/h, with increments of 0.5 km/h each minute (Léger et al., 1984).(Bandyopadhyay et al., 2019; Mayorga-Vega et al., 2015; Przysucha et al., 2019) The participants need to run continuously between two lines 20-m apart while keeping pace as signalled by the pre-recorded audiotape. The test was terminated when the athlete could not reach the line with the audio signals on two consecutive occasions. (Przysucha et al., 2019).

Statistical Analysis

All statistical analysis were performed using SPSS version 25.0. Data normality was confirmed with Shapiro-wilk test. We examined the difference between the Group I, Group II and Group III by ANOVA test. Data were expressed as mean values and included standard error of the mean (SEM;±). A criterion alpha level of $p<0.05$ was used to determine the statistical significance.

Results

Table 1: Descriptive Statistics according to the Groups

DESCRIPTIVE STATS						
VARIABLES	SIRT		SSG		GENERIC	
	MEAN	SD	MEAN	SD	MEAN	SD
AGE(years)	17.40	3.56	18.40	3.20	16.69	1.54
HEIGHT(cm)	168.23	7.59	169.40	6.77	170.76	6.99
WEIGHT(kg)	60.53	5.86	62.73	6.10	64.03	6.06
BMI(kg/cm^2)	21.36	1.09	21.82	1.12	21.92	0.85
TRAINING AGE(years)	4.43	2.90	4.53	2.37	3.00	1.75
AGILITY by T-Test	11.85	0.62	11.93	0.70	11.89	0.58
VERTICAL JUMP	31.59	4.41	31.33	4.21	29.12	5.12
10m SPRINT	2.31	0.15	2.24	0.13	2.29	0.16
RSA	45.25	0.58	45.48	0.60	45.44	0.58
VO_2 MAX	77.78	2.26	80.39	2.18	80.23	2.06
RMSSD	68.12	48.73	74.66	45.73	115.84	53.57
LF	1946.09	1935.48	2511.38	2884.67	1910.37	2206.37
HF	2394.39	3535.53	3289.54	4183.83	1157.59	2124.83
LF/HF RATIO	1.52	1.99	0.95	0.50	3.19	2.17

Table 2: Comparison between pre and post intervention scores of SIRT

COMPARISON BETWEEN PRE and POST INTERVENTION OF SIRT GROUP- AGILITY							
VARIABLES	PRE		POST		95% CI		p-VALUE
	MEAN	SD	MEAN	SD	LOWER	UPPER	
AGILITY	11.85	0.62	11.56	0.61	-0.32	-0.28	<0.001
10 M SPRINT	2.31	0.15	2.17	0.14	-0.15	-0.14	<0.001
VERTICAL JUMP	31.59	4.41	36.63	4.65	4.57	5.52	<0.001
RSA	45.25	0.58	45.75	0.55	0.46	0.54	<0.001
VO2 MAX	77.78	2.26	80.58	2.12	2.56	3.04	<0.001
RMSSD	68.12	48.73	108.00	57.81	31.30	48.44	<0.001
LF	1946.09	353.37	1972.08	460.70	-481.85	533.82	0.917
HF	2394.39	645.50	1193.58	399.71	-1881.00	-520.62	<0.001
LF/HF RATIO	1.52	1.99	3.18	2.97	1.05	2.28	<0.001

Table 3: Comparison between pre and post intervention scores of SSG

COMPARISON BETWEEN PRE and POST INTERVENTION OF SIRT GROUP- AGILITY							
VARIABLES	PRE		POST		95% CI		p-VALUE
	MEAN	SD	MEAN	SD	LOWER	UPPER	
AGILITY	11.93	0.70	11.73	0.70	-0.20	-0.18	<0.001
10 M SPRINT	2.24	0.13	2.17	0.13	-0.08	-0.06	<0.001
VERTICAL JUMP	31.33	4.21	33.77	4.22	2.22	2.64	<0.001
RSA	45.48	0.60	45.78	0.61	0.29	0.32	<0.001
VO2 MAX	80.39	2.18	82.55	2.16	2.11	2.22	<0.001
RMSSD	74.66	45.73	66.38	45.04	-11.73	-4.83	<0.001
LF	2511.38	2884.67	2306.06	2401.89	-1154.06	743.44	0.661
HF	3289.54	4183.83	2920.10	3296.69	-1739.95	1001.08	0.586
LF/HF RATIO	0.95	0.50	1.00	0.53	-0.03	0.15	0.186

Table 4: Comparison between pre and post intervention scores of GENERIC (Control)

COMPARISON BETWEEN PRE and POST INTERVENTION OF GENERIC (Control) GROUP-AGILITY							
VARIABLES	PRE		POST		95% CI		p-VALUE
	MEAN	SD	MEAN	SD	LOWER	UPPER	
AGILITY	11.89	0.58	11.78	0.57	-.12	-.10	<0.001
10 M SPRINT	2.29	0.16	2.26	0.16	-.03	-.03	<0.001
VERTICAL JUMP	29.12	5.12	30.14	4.96	.85	1.20	<0.001
RSA	45.44	0.58	45.60	0.57	.13	.18	<0.001
VO2 MAX	80.23	2.06	81.68	2.03	1.31	1.59	<0.001
RMSSD	115.84	53.57	71.60	46.59	-53.22	-35.25	<0.001
LF	1910.37	2206.37	1280.85	768.12	-1456.59	197.56	0.130
HF	1157.59	2124.83	1330.46	1175.83	-660.80	1006.53	0.675
LF/HF RATIO	3.19	2.17	1.55	1.17	-2.26	-1.04	<0.001

Table 5: One way ANOVA analysis of difference between variables in groups.

ONE WAY ANOVA ANALYSIS OF DIFFERENCE BETWEEN VARIABLES IN GROUPS-AGILITY								
VARIABLES	SIRT		SSG		GENERIC		f-VALUE	p-VALUE
	MEAN	SD	MEAN	SD	MEAN	SD		
AGILITY	0.30	0.05	0.19	0.02	0.11	0.03	192.196	<0.001
10m SPRINT	0.15	0.02	0.07	0.02	0.03	0.01	272.203	<0.001
VERTICAL JUMP	5.05	1.27	2.43	0.56	1.03	0.46	175.799	<0.001
RSA	0.50	0.11	0.30	0.04	0.16	0.07	152.908	<0.001
VO2 MAX	2.80	0.64	2.16	0.14	1.45	0.37	72.7	<0.001
RMSSD	39.87	22.95	-8.28	9.24	-44.23	24.06	134.595	<0.001
LF	25.98	1360.02	-205.31	2540.81	-629.51	2214.95	0.753	<0.001
HF	-1200.81	1821.57	-369.44	3670.30	172.87	2232.60	1.979	<0.001
LF/HF RATIO	3.18	2.97	1.00	0.53	1.55	1.17	11.069	<0.001

Pre- intervention and post- intervention results was analysed and compared. The difference in agility was more in the SIRT group (increase by 0.30±0.05) as compared the SSG (increase by 0.19±0.02) and Generic (control) group (increase by 0.11±0.03). This difference was statistically significant ($p<0.001$). Comparing the three groups, more significant increase in score of vertical jump was seen in SIRT group (decrease by 5.05±1.27) as compared to the SSG group (increase by 2.43±0.56) and Generic(Control) group (increase by 1.03±0.46) . This change was significant. ($p<0.001$). Comparing the three groups, more significant increase in score of 10 m sprint was seen in SIRT group (increase by 0.15±0.02) as compared to the SSG group (increase by 0.07±0.02) and Generic(Control) group (increase by 0.03±0.01) . This change was significant. ($p<0.001$). The difference in VO_2 max was more in the SIRT group (increase by 2.80±0.64) as compared to the SSG group (increase by 2.16±0.14) while it increased only by 1.45±0.37 in the Generic (control) group. This difference was statistically significant ($p<0.001$). Comparing the three groups, a significant increase in RMSSD was seen in SIRT group (increase by 39.87±22.95) as compared to the SSG group (decrease by 8.28±9.24) and Generic (Control) group (decrease by 44.23±24.06) which saw a decrease. This change was significant. ($p<0.001$).

Discussion

The results of this study in all the three groups revealed a statistically significant improvement in agility, sprint performance, vertical jump, repeated sprint ability, aerobic capacity and Heart rate variability for both time and frequency domain parameters and nonlinear analysis reflecting an overall improvement in Functional independence, fitness level, endurance capacity and cardiac autonomic control. High intensity interval training improved all the parameters in all the three group shows trends towards adaptation and is statistically significant. Indeed, sided games produce similar cardiovascular stress as other intermittent exercises specifically designed to improve athletes' endurance.

The main findings were that both training programs were equally effective at improving all performance measures in the Indian elite soccer players. The results of this study revealed that a 6-week period soccer training including SIRT and SSG with control group significantly increased the aerobic capacity. SIRT and SSG increases the performance in the agility test suggesting that players were more accustomed with the directional changes and, therefore, have improved their specific fitness performance. This type of short-duration intermittent exercise solicits the anaerobic and aerobic mechanisms at the same time. The present study showed that the 15–15-s intermittent exercise at a lower intensity, i.e., 100% VO2max, was insufficient to induce a high HRV response, showing the importance of the choice of exercise intensity in intermittent training. These results confirm the fact that the development of V O2max requires an exercise intensity higher than 100% of VO2max when short-duration intermittent running is considered(Dellal et al. 2008)(Alexandre et al. 2012).

The performance in the 10m and 30m sprint performance correlated with the repeated sprint ability test in inducing comparable levels of lactic acidosis and post exercise autonomic state. The results of the present study demonstrated that 6 weeks of training including SSGs in elite soccer players during the midseason period significantly improved both the aerobic performance and the dynamic strength ability to vertical jump height similar to SIRT group. However, no difference between both training groups for the aerobic performance by multistage fitness test and the performance in the repeated sprint test was found. These results suggest that SIRT and SSGs may equally improve the aerobic metabolism, peripheral component, and anaerobic energetic system (H+ regulation and buffer capacity) re-creating the intermittent nature of a soccer game. One of the differences between sided games and short-duration intermittent running training methods is the presence of the ball, which imposes a specific activity and allows the concomitant improvement of technical and tactical skills with high player motivation(Kunz et al. 2019).

Results of the present study suggest that aerobic demand and speed of SIRT and SSG are comparable and considered to be similar. Whereas, static explosive strength and muscular endurance are statistically significantly higher after intervention in all three group in soccer players. The result didn't indicate that one group is stronger than the other. The measures performed in this study were conducted in a standardized situation and followed strict guidelines, and therefore, these measures provide valuable insights into the physical fitness, body compositions, anthropometric profile, and heart rate variability of soccer players. Also, the knowledge from this research helps coaches and trainers to develop sports-specific training programs.

In conclusion, these findings showed that some small-sided games allow the HRV to increase to the same level as that in short-duration intermittent running. The sided game method can be used to bring more variety during training, mixing physical, technical, and tactical training approaching the intensity of short-duration intermittent running but with higher intersubject variability.

Conclusion

In conclusion, these findings showed that some small-sided games allow the HRV to increase to the same level as that in short-duration intermittent running. In conclusion, the results of the present study suggest improvements promoted by intensive training phase in elite soccer players, especially in HRV which shows parasympathetic adaptation.

Practical implication

These results have important practical implications because these parameters can be assessed longitudinally to monitor adaptation and maladaptation to training with impact on aerobic and anaerobic performance in elite soccer players.

Limitation of the study

The results are restricted to the specific moment of the season that we assessed i.e. intensive training phase. We could not control appropriately training load distribution along the six weeks because we were not allowed to interfere in training prescription.

Future Research

The runners to be well-rested, well-nourished and well-hydrated before maximal tests and all the training sessions, a 24-h recall to measure daily caloric intake was not taken into account.

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