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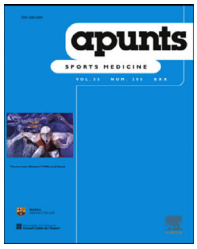

ORIGINAL ARTICLE

Effects of high-intensity interval training versus sprint interval training during the second wave of COVID-19 lockdown on soccer players

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Abstract This study aimed to compare the effects of two intervention programs (i.e., high-intensity interval training [HIIT] versus sprint interval training [SIT]) during the second wave of pandemic COVID-19 in semi-professional soccer players. Twenty-nine male soccer players were divided into two groups: HIIT (N: 16, age: 19.6 ± 2.4 years, height: 1.8 ± 0.5 m, weight: 71.5 ± 4.6 kg, and body fat: 7.3 ± 2.6%), who performed a HIIT protocol with progressive intensity and resistance training; SIT (N: 13, age: 23.5 ± 5.1 years, height: 1.8 ± 0.1 m, weight: 74.0 ± 4.5 kg and body fat: 8.8 ± 2.6%) that performed a SIT program combined with body weight circuit training. According to the instructions from World Health Organization of basic protective measures against COVID-19, each session did not exceed 60 min. Aerobic capacity (Yo−Yo IR1) and countermovement jump (CMJ) height were measured before and after a 4-week intervention period. Aerobic variables (maximum oxygen uptake [$\dot{V}O_{2max}$], velocity at $\dot{V}O_{2max}$ [$v\dot{V}O_{2max}$] and CMJ significantly increased ($p<0.001$), while maximum heart rate [HRmax] decreased ($p<0.01$) following the HIIT intervention program. Conversely, values remained unchanged in the SIT group after the training. Post-evaluation between-group comparisons revealed that $\dot{V}O_{2max}$ was significantly higher in HIIT when compared to SIT ($p<0.05$). These results suggest that HIIT combined with resistance training, in different sessions, could lead to superior improvements in endurance and vertical jump ability in short time periods when compared to the combination of SIT and body-weighted strength training in semi-professional soccer players.
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Introduction

These last years, due to the COVID-19, sport leagues, tournaments, and athletes regulations changed worldwide.[1] During the COVID-19 era, players' training and game schedule,

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physical performance, nutrition, and sleep habits were affected.[2,3] The easy transmission of the virus prompted sports authorities to take restrictive measures for athletes who were infected. For example, soccer players were forced into quarantine lasting from 15 days (during the first months, June – November 2020, following the obligatory lockdown) until 3 days (December 2021– February 2022), in case that athlete's condition was adequate. Specifically, in the second wave of the pandemic (early November 2020– January 2021), Super League (1st Division of Greece), 2nd, 3rd Division of Greece, and regional leagues were interrupted after the 3rd fixture. The authorities proceeded to a training restriction on 7/11/2020 setting for a possible re-start of the league in January 2021.

During the first lockdown (i.e., end of February 2020 – May 2020), home-based training programs and nutritional instructions were provided to soccer players in order to maintain fitness levels for the re-start of competition.[2-5] However, several studies demonstrated that such strategies were not as effective as expected since declines in physical performance and more injuries were reported in different team-sports.[6-12] For example, a study with professional Brazilian soccer players revealed significant decreases in countermovement jump (CMJ) and sprint (i.e., 10 and 20 m) performances after the quarantine.[13] Similarly, another study[14] demonstrated that elite soccer players, despite being able to maintain CMJ height, significantly declined in metrics such as reactive strength index, and peak concentric and eccentric power during the lockdown. However, additional research in neuromuscular and physiological components is still needed to better understand the effects of different high intensity programs applied during the second wave of COVID-19 quarantine through the course of the competitive season as most of the studies used moderate load training regimes.

The purpose of this study was to compare two 4-week intervention programs, high-intensity interval training (HIIT) and sprint interval training (SIT) applied during the second wave of COVID-19, in aerobic capacity and jumping ability in semi-professional soccer players. It was hypothesized that endurance and neuromuscular capacity would improve for both groups (i.e., HIIT and SIT).

Material and methods

Study design

An experimental study was designed to compare two intervention programs of 4 weeks, in aerobic (i.e., YO – YO Intermittent Recovery [IR] 1) and jumping capacity (i.e., CMJ height). All participants were familiar with the performance evaluations as they regularly completed them every season. Because of the COVID-19 pandemic, Greek professional and semi-professional leagues were interrupted after the 3rd fixture (November 2020) until March 2021. During the intermission, two different intervention programs were implemented (i.e., HIIT and SIT). In the 1st week, players realized a COVID-19 rapid test, and after negative results they proceeded to the measurements. Body composition and anthropometric measurements were completed in the morning (08:00 a.m.), while the vertical jump and endurance field test were performed in the afternoon (16:30 p.m.). In the 5th week (i.e., after the 4-week intervention period), players repeated the measurements, in the same way, order, and with the same researchers. Players who contracted the virus or got injured during the lockdown were excluded from the study.

Participants

Twenty-nine semi-professional soccer players of two teams participated. Sixteen of them (age: 19.6 ± 2.4 years, height: 1.8 ± 0.5 m, weight: 71.5 ± 4.6 kg and body fat: $7.3 \pm 2.6\%$) were in the HIIT group and competed in 3rd National Division of Greece, while the other thirteen (age: 23.5 ± 5.1 years, height: 1.8 ± 0.1 m, weight: 74.0 ± 4.5 kg and body fat: $8.8 \pm 2.6\%$) were in SIT group and competed 4th Division of Greece. All players were healthy, do not have any injury, and did not receive any medication or illegal nutritional supplements. All procedures were in accordance with the Declaration of Helsinki of 1975, as revised in 2000 and approved by the university ethics committee, while all participants signed a written informed consent before entering in the research procedure.

Procedures

Training protocols

HIIT group performed 3 running-based sessions without a ball per week and 2 weekly strength training workouts using free weights. In the 1st week, the aerobic training was prescribed as follows: 6 sets of 6 min at 85% of $v\dot{V}O_{2max}$. The 2nd week consisted of 4 sets of 6 min at 90% of $v\dot{V}O_{2max}$ and the 3rd week contemplated two sessions in which players performed 5 sets of 4 min and a third session of 4 sets of 4 min at 95% of $v\dot{V}O_{2max}$. Finally, in the last week, 4 sets of 4 min at 100% of $v\dot{V}O_{2max}$ were completed in each session. A 3 min recovery between sets was prescribed (Table 1). Strength training consisted of bench press, half-squat, clean, hip-trust, leg flexion and extension (i.e., 3–5 sets with 3–8 repetitions), with 1 min rest between sets for each exercise and with 3 min rest between exercises and intensity from 65 to 95% of 1RM was prescribed.

SIT group completed 3 running-based sessions per week, without a ball, and 2 body weight circuit training sessions a week. Players performed in the 1st training, 1 round with 10 sets with 10 s running at 95% $v\dot{V}O_{2max}$ and 20 s rest. In the 2nd training, 2 rounds of 8 sets with 30 s running at 100% $v\dot{V}O_{2max}$ and 30 s rest. Lastly, in the 3rd training contained 2 rounds with 3 sets of 2 min running at 105% $v\dot{V}O_{2max}$ and 2 min rest. This program repeated every week with total running duration 33 min (Table 1). The strength training program was the same during the 4 weeks and consisted of push-ups, squats, TRX row, dumbbell row, jumping jack, mountain climbers four sets with 30 s work and 30 s rest for all exercises and 3 min rest between sets.

Vertical jump

CMJ performed on an electronic contact mat (CHRONOJUMP – Bosco system, Din-A4 297×210 m, Spain). Players were instructed to perform a downward movement until 90° knee flexion followed by a complete extension of the lower limbs with the hands fixed on the hips during the

Table 1 Prescription of the exercise protocols.

HIIT					
Week	1st	2nd	3rd		4th
Days	–	–	1st	2nd	–
Sets	6	4	5	4	4
Duration	6 min	6 min	4 min		4 min
Intensity	85% vV̇O2max	90% vV̇O2max	95% vV̇O2max		100% vV̇O2max
Rest	3 min	3 min	3 min		3 min

SIT			
Week	4-week period		
Days	1st	2nd	3rd
Rounds	1	2	2
Sets	10	8	3
Duration	10 s	30 s	2 min
Intensity	95% vV̇O2max	100% vV̇O2max	105% vV̇O2max
Rest	20 s	30 s	2 min

HIIT: high-intensity interval training; SIT: sprint-interval training.

entire movement. Three separate jumps on the platform with the aim of achieving maximal jump height, with 30 s of recovery between jumps were allowed. The highest of the 3 jumps was selected as measured by flight time calculations.[15]

Aerobic capacity

The YO-YO IR 1 used to evaluate aerobic capacity. The test consisted of repeated 2 × 20 m runs back and forth between the starting, turning, and finishing line at a progressively increased speed controlled by audio beeps from a CD computer with speakers. Between each running bout, the subjects had a 10 s active rest period, consisting of 2 × 5 m of jogging. The test ended when the subjects failed twice to reach the finishing line within the available time and the total distance covered was recorded. $\dot{V}O_{2max}$ was then derived from Bangsbo's equation.[16] The speed of $\dot{V}O_{2max}$ ($v\dot{V}O_{2max}$) was estimated from previously published equations.[17] Heart rate (HR) was recorded for each player every 5 s using a monitor with belt wireless strapped around the chest (Suunto Team POD, Dual Comfort Belt, Finland).

Statistical analysis

The statistical analysis was performed with the STATISTICA software (Version 12, USA). A two-way ANOVA with repeated measures pre- and post-COVID-19 restriction of two groups was used. If a significant interaction was found, post-hoc was performed and an Unequal N HSD *t*-test analysis was used. Cohen's effect sizes (ESs) with 95% confidence intervals (95% CI) were computed to determine the magnitude of every paired comparison and classified as: trivial (<0.2), small (>0.2–0.6), moderate (>0.6–1.2), large (>1.2–2.0), and very large (>2.0–4.0).[18] The level of significance was set at $p<0.05$.

Results

All data are presented as mean and standard deviation (SD). Significant differences ($p<0.05$) were found in total training time in HIIT when compared to SIT (Table 2). No significant differences were found between the two groups (HIIT versus SIT) in body fat, height, and weight ($p>0.05$), however, HIIT group were significant younger than SIT group ($p<0.05$). No significant differences were observed in pre-COVID-19 evaluations between groups. Following the 4-week program, the HIIT group covered a significantly greater distance in YO-YO IR1 ($p<0.001$; ES: 2.7; 95% CI: 3.7 – 1.6), while achieving higher $\dot{V}O_{2max}$ ($p<0.001$; ES: 2.7; 95% CI: 3.7 – 1.6), $v\dot{V}O_{2max}$ ($p<0.001$; ES: 2.7; 95% CI: 3.7 – 1.6), CMJ height ($p<0.001$; ES: 1.6; 95% CI: 2.3 – 0.8), and lower value of HRmax ($p<0.01$; ES: 0.8; 95% CI: 0.2 – 0.8) when compared to the baseline (Fig. 1 and Table 3). Considering post measurements between group differences, greater ($p<0.05$) distance covered, $\dot{V}O_{2max}$ and $v\dot{V}O_{2max}$ were found in HIIT group when compared to SIT (Table 3).

Discussion

The aim of the present 4-week study was to evaluate the effects of two training programs (HIIT versus SIT) on the performance of semi-professional soccer players during the 2nd wave of COVID-19. The main results were the following: 1) significant pre-post improvements were found in the HIIT group for YO-YO IR 1 total distance, $\dot{V}O_{2max}$, $v\dot{V}O_{2max}$, CMJ height, and HRmax following the 4-week intervention; 2) non-significant differences were obtained in the same variables for the SIT group; and 3) the HIIT protocol yielded superior adaptations as seen by the significant differences found in YO-YO IR1 variables at post-test when compared to SIT.

Regarding endurance capacity, significant pre-post improvements were found in the HIIT group for YO-YO IR 1 total distance, $\dot{V}O_{2max}$, $v\dot{V}O_{2max}$, and HRmax following the 4-

Table 2 Total training time during the 4-week program.

		Weeks								Total Time	
		1st		2nd		3rd		4th			
Training items	Time	HIIT	SIT	HIIT	SIT	HIIT	SIT	HIIT	SIT	HIIT	SIT
Warm-up	(min)	50	50	50	50	50	50	50	50	200	200
Interval training	(min)	108	33	72	33	60	33	48	33	288	132*
Strength training	(min)	120	120	120	120	120	120	120	120	480	480
Cool-down	(min)	50	50	50	50	50	50	50	50	200	200
Total Time	(min)	328	253	292	253	280	253	268	253	1168	1012
Number of sessions per week		5	5	5	5	5	5	5	5	20	20

* Statistically significant difference ($p<0.05$) in total minutes of interval training between groups HIIT and SIT.
HIIT: high-intensity interval training; SIT: sprint interval raining.

week intervention. To author's knowledge, this is the first study to research about the high-intensity training regimen during COVID-19 restriction. These results could be explained by the intensity (i.e., vVO_{2max}), as higher velocity than $\dot{V}O_{2max}$, cardiac output and stroke volume reach lower values than at lower $\dot{V}O_{2max}$ velocity.[19] Also, the enzymatic adaptations related to anaerobic capacity, training intensity should be near to maximum (~90% VO_{2max}) and for this may explain the results obtained in the SIT group that remained unchanged.[20,21] The findings of the present research are in line with the research of Helgerud et al.,[22] who applied HIIT and moderate-intensity continuous running programs for 4 weeks and found that HIIT significantly improved $\dot{V}O_{2max}$ when compared to moderate intensity running. In the present study, the duration of the SIT program was short and the maximum intensity exceeded $v\dot{V}O_{2max}$, with the result other cardiorespiratory and neuromuscular adaptations were involved[20,23]. In applied settings, intensities close to $\dot{V}O_{2max}$ may be better solution to improve the aerobic-anaerobic performance when compared to SIT program in a short-term period without competition in semi-professional soccer players.

Considering jumping ability, no significant changes were observed in the SIT group while the HIIT group jumped higher after the 4-week training program (despite the absence of between-group differences at post-test). This could be explained, at least in part, by the fact that the resistance training and HIIT sessions were not performed in the same day and sufficient recovery was provided between the training sessions in order to avoid interference phenomenon.[24,25] The difference between pre-season and the 4-week intervention period during in-season, was the level of fatigue that players were exposed to, as in the current study, the 4-week period was not considered as preparation period, because of the government's regulations (maximum 1 h training exposure and individually training) and lack of soccer-specific training schemes. During the pre-season period in soccer, there is high level of training stress, with double training sessions, and friendly matches.[21,24,26,27] Lastly, circuit body weight training could maintain the CMJ height, however, it did not present further improvements.

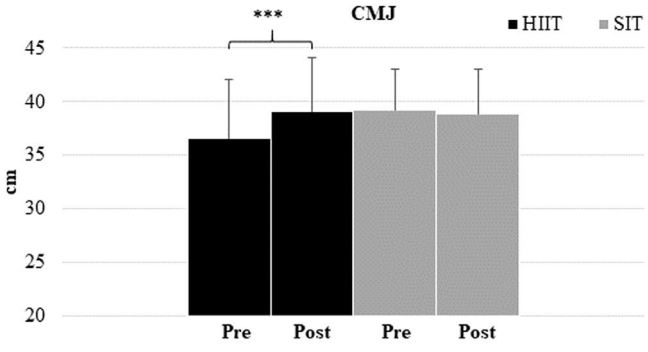

Fig. 1 Countermovement jump pre- and post-4-week program. ***Statistically significant difference ($p<0.001$) pre and post. HIIT: High-Intensity Interval Training; SIT: Sprint Interval Training.

This study is limited by its design; however, it is important to highlight that subjects were part of soccer teams where each coaching staff decided the intervention program. Furthermore, no further information was registered, such as the rating of perceive exertion or technology tracking system for the training session, which could complement the load of the training. More neuromuscular tests (i.e., sprint, change of direction, and CMJ jump landing metrics) is warranted in order to detect the effects of the 4 weeks break of competitive season because of second wave of COVID-19 lockdown.

Conclusion

In conclusion, the present study demonstrated HIIT improved endurance and vertical jump height when compared to SIT. Moreover, intensities close to $\dot{V}O_{2max}$ may be a better solution to improve the aerobic performance when compared to SIT program in a short-term period without competition in semi-professional soccer players.

Practical applications

During the sudden interruption due to the spread and transmission of COVID-19 or in similar cases of detraining periods, sports practitioners may use a similar intervention program to HIIT in order to improve the endurance and jumping capacity. In addition, the present study demonstrated that

Table 3 Aerobic and maximum heart rate variables of YO-YO IR1 test at pre- and post-intervention program.

	$\dot{V}O_{2max}$ (ml^{-1} kg^{-1} min^{-1})				$v\dot{V}O_{2max}$ (km h^{-1})				Meters				HRmax (bpm)			
	HIIT		SIT		HIIT		SIT		HIIT		SIT		HIIT		SIT	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	54.88	59.74 **	56.50	55.33 †	16.65	18.19**	17.71	17.52 †	2200	2779**	2393	2254 †	194.69	191.06*	193.38	192.92
SD	2.94	3.75	3.41	4.54	0.93	1.19	0.85	1.13	361	462	438	583	6.50	6.97	9.70	8.75

* Statistically significant difference ($p<0.01$) pre and post.
** Statistically significant difference ($p<0.001$) pre and post.
† Statistically significant difference ($p<0.05$) in post between groups HIIT and SIT.
HIIT: high-intensity interval training; SIT: sprint interval training; HRmax: maximum heart rate expressed bump per minute; SD: standard deviation; $\dot{V}O2max$: maximum oxygen output expressed ml per body mass per minute; $v\dot{V}O2max$: velocity of the maximum oxygen output expressed by kilometers per hour.

the SIT program was not effective in increasing endurance capacity in semi-professional soccer players in short-term preparation period.

Conflicts of interest

The authors have no conflict of interest of this study

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