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Three workouts compared: interval training, intermittent training and steady state training for the improvement of VO_2max and BMI

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Declaration
The study adhered to ethical code of the Declaration of Helsinki and written informed consent was obtained from all participants.

Abstract: *An optimal soccer training, among many objectives, should allow both the improvement of VO2max, or the maximum oxygen supply, and of the anthropometric data. The purpose of the study was to examine the effects of intermittent training, interval training and steady state training methodologies on VO2max and BMI of the players. The sample was made up of 30 young amateur players (age, Mean ± standard deviation [SD] = 16 ± 0.74 years old) randomly divided into three 3 groups of 10. Each group performed a different resistance training methodology for 3 months: group 1 performed intermittent training, group 2 interval training and group 3 steady state training. The parameters taken into consideration were BMI and VO2max, obtained from Gacon test. Paired Sample T Test was performed to check the difference between pre and post 12 training weeks of each group regarding VO2max and BMI. A 3x2 mixed ANOVA was used to test for differences in training programs induced changes in maximal strength and functional capacity variables. The independent variables included one between-subjects factor (training intervention) with three levels (IT, HIIT, and SST), and one within-subject factor (time) with two levels (pre- and post-intervention). A significant difference ($p<0.05$) between pre and post all of the three training protocols on VO2max was found, but no significant interaction ($p>0.05$) between group and time. BMI had no significant improvement ($p>0.05$). Intermittent, interval and endurance training all were equally effective improving VO2max, but not BMI.*

Keywords: *soccer, resistance, VO2max, BMI, training method.*

Introduction

Soccer has become one of the most famous sports in the world (Dvorak et al., 2004; Reilly et al., 2000) requiring excellent technical, tactical, mental and motor training (Kalinowski et al., 2019; Kalinowski et al. , 2020). On a performance level, football involves explosive physical actions that require strength, power and agility (Katushabe & Kramer, 2020). In particular, the aerobic capacity of athletes is an important element of success in sports results (Rankovic et al., 2010); in fact, it plays a key role in competitive football (Federici et al., 2019; Raiola & Altavilla, 2020). An optimal football training, among other objectives, should improve both maximal oxygen uptake (VO_2max) and body mass index (Calandro et al., 2020). Maximum oxygen uptake (VO2max) refers to the intensity of aerobic processes (Coppola & Raiola, 2019), and effectively represents the body's ability to use the maximum amount of oxygen at a given time (Živanić et al., 1999). It is the highest rate of oxygen consumption attainable during maximal/exhaustive exercise (Wilmore & Costill, 2005). Research suggests that the aerobic system is the main source of energy in football, looking at the duration of work and rest (Belegišanin, 2017). Consequently, aerobic fitness tests are performed regularly in soccer players, to assess Vo_2max, such as Gacon test. Several studies used Gacon, a valid and reliable test in soccer (Castagna et al., 2014) to assess VO_2max (Calandro et al., 2020; Pastore et al., 2019). The assessment of endurance in young players is of fundamental importance (Ceruso et al, 2019). The development and training of endurance is a focal point in the growth of all players (Esposito et al, 2019). Training endurance improves the aerobic power of the athlete. Three methods are used to improve aerobic endurance: intermittent training, interval training and steady state training. High intensity interval training, called HIIT, or intermittent, is a very popular form

of exercise, as it takes little time and results in excellent results (Foster et al., 2015), characterized by alternating maximum effort and actively performed recovery (Gaetano & Rago, 2014). According to a study (Calandro et al., 2020), Intermittent training was useful and brought about an improvement in BMI as well as in VO_2max. Interval training is another method improving aerobic capacity (Billat, 2001), whose peculiarity is the variation in training intensity: it goes from low-impact to high-intensity exercises. Recovery can be active or passive, unlike HIIT, where recovery is always active. Steady State Training (SST) or constant training, on the other hand, is the third methodology that involves prolonged training over time. The cardiac rate is constant usually within a period ranging from moderate to medium-high intensity (physical effort), roughly between 60 and 80% of your maximum heart rate (HRmax), or between 50 and 75% of the maximum oxygen consumption VO_2max (Francini et al., 2019). It is certainly much easier to program: it requires extended time and constant frequency. Each type of physical activity always brings changes to the body. Training determines physiological effects with consequent functional responses that promote an improvement in performance (D'Isanto et al., 2020; Izzo et al., 2020). The observed training-induced changes in body composition, aerobic capacity, anaerobic power and strength can be attributed to appropriate load dynamics (B&S, 2014). However, scientific evidence is insufficient to determine which method is best for improving aerobic endurance (Barker, 2004) and BMI. The aim of the study was to examine the effects of the methodologies of intermittent training, interval training and steady state training on the VO_2max and BMI of the players taken into consideration.

Methods

Participants

The present study was designed to describe the characteristics of 30 players (age, mean ± standard deviation [SD] = 16 ± 0.74 years), who participated in the under 17/16 regional championship in 2021. To be included in the study, athletes had to be injury-free and no training suspension in the previous 6 months. All players were familiar with the use of the three training methods. Data were stored and processed anonymously.

Design and data collection

Anthropometric parameters, such as weight and height, from which the BMI is derived, were measured before and after 12 weeks. BMI is considered a generic index of a player's physical fitness and is very useful because it allows players to be classified into categories. In young people, BMI has considerable variability related mainly to age and sex, so for this parameter the percentiles and the Z score BMI-for-age (5-19 years) by WHO (World Health Organization) were calculated with a software. A detailed description of BMI benchmarks is shown in Table 1.

Table 1. *BMI benchmarks*

CLASSIFICATION	PERCENTILES
Underweight	<5
Normal weight	≥5 e <85
Overweight	≥85 e <95
Obese	≥95

Next, the players performed Gacon test before and after 12 training weeks to determine VO_2max. The test consists of alternating running sections of 45 s, with recovery periods of 15 s. The initial speed is 10 km/h, which corresponds to a section of 125 m (covered in 45 s). The initial speed is 10 km/h, which corresponds to a stretch of 125 m (run in 45 s). After a break of 15 s, a further 6.25 m is run (total 131.25 m, or 10.5 km/h) and so on until the athlete can no longer cover the planned distance in 45 s.

Training protocol

The players were randomly divided into 3 groups of 10 athletes, each of whom carried out a different training protocol. All athletes performed the protocol training twice a week in the preparation phase and once a week in the competition phase.

Group 1 *(G1) performed intermittent training (HIIT), as follows.*

G1	Workouts/ week	Sprints/week	Sprint duration (s)	Rest duration (s)	Rest intensity
Week 1	2	4	10 s	10 s	1
Week 2	2	6	10 s	10 s	1
Week 3	2	8	10 s	10 s	1
Week 4	2	4	20 s	20 s	1
Week 5	2	6	20 s	20 s	1
Week 6	2	8	20 s	20 s	1
Week 7	2	4	30 s	30 s	1
Week 8	2	4	30 s	30 s	1
Week 9	2	4	30 s	30 s	0-1
Week 10	3	4	30 s	30 s	0-1
Week 11	3	4	30 s	30 s	0-1
Week 12	3	4	30 s	30 s	0-1

Group 2 *(G2) performed interval training (IT), as follows.*

Week	Time repetition	Time sprint	Repetition	Pause
1	5’33”	45”	3	35”
2	5’33”	45”	3	35”
3	5’33”	45”	3	35”
4	5’33”	50”	3	30”
5	5’33”	50”	3	30”
6	5’33”	50”	3	30”
7	7’	45”	3	25”
8	7’	45”	3	25”
9	7’	45”	3	25”
10	8’	45”	2	15”
11	8’	45”	2	15”
12	8’	45”	2	15”

Group 3 *(G3) performed steady state training (SST), as follows.*

Volume	Repetition	Pause
Da 30’ a 45’/50’	1	End repetition
Da 2 a 4 Km	4x500mt	3’
Da 2 a 4 Km	3x1000mt	4’
Da 2 a 4 Km	500-1000-1500-500mt	3’-3’30”-4’

Statistical analyses

After verifying the normality of the data with the Kolmogorov-Smirnov test, the central tendency and dispersion indices were calculated. Paired Sample T Test was performed to check the difference between pre and post 12 training weeks of each group against VO_2max and BMI. A 3x2 mixed ANOVA was perfomed to test for differences in training programs induced changes in maximal strength and functional capacity variables. The independent variables included one between-subjects factor (training intervention) with three levels (IT, HIIT, and SST), and one within-subject factor (time) with two levels (pre- and post-intervention). To examine the influence of training intervention on the development of our dependent variables, we used these ANOVAs to test the null hypothesis of no different change over time between groups (training intervention × time interaction). To qualitatively interpret the magnitude of differences, effect sizes (d) and associated 95% confidence intervals (95%CI) were classified as small (0.2–0.5), moderate (0.5–0.8) and large (>0.8). Statistical analyzes were performed using the Statistical Package for Social Sciences (SPSS 15.0 for Windows) software. The level of significance was fixed at $p < 0.05$.

Results

A detailed description of anthropometric characteristics' results before the administration of the training protocol is shown in Table 2.

Table 2. *Anthropometric characteristics of pre and post training players*

Players	Age	Pre					Post				
		Weight	Height	BMI	Z score	Percentiles	Weight	Height	BMI	Z score	Percentiles
Player 1	17	67.2	183	20.1	-0.5	32.6	67.3	183	20.1	-0.4	33
Player 2	17	82	190	22.7	0.5	68.1	86	190	23.8	0.8	77.9
Player 3	16	50.2	170	17.4	-1.5	6.7	47.8	170	16.5	2	2.1
Player 4	17	63.5	171	21.7	0.2	56.4	61.5	171	21	-0,1	46.8
Player 5	16	57.3	177	18.3	-1	16.4	56.3	177	18	-1.2	12.5
Player 6	16	55.9	172	18.9	-0.7	24.5	52.9	172	17.9	-1.0	14.9
Player 7	16	46.8	160	18.3	-1	16.1	44.8	160	17.5	-1.2	11.5
Player 8	16	86	185	25.1	1.2	89.1	88	185	25.7	1.3	91
Player 9	16	48.6	160	19	-0.6	26.1	45.6	160	17.8	-1.2	10.7
Player 10	16	63.3	181	19.3	-0.5	31.2	62.3	181	19	-0.6	26.4
Player 11	16	68.5	177	21.9	0.4	66.6	66.5	177	21.2	0.2	59.1
Player 12	16	69.2	177	22	0.5	69.1	68.2	177	21.8	0.4	65.5
Player 13	17	59.5	169	20.8	-0.1	44	57.5	169	20.1	-0.4	33.4
Player 14	17	82	186	23.7	0.7	77	80	186	23.1	0.6	72.2
Player 15	17	60	180	18.5	-1,2	11.9	59	180	18.2	-1,4	8.9
Player 16	17	66.5	182	20.1	-0,4	32.6	66.5	182	20.1	-0,4	32.6
Player 17	17	68.5	175	22.4	0.4	64.4	66.5	175	21.7	-2.6	0.5
Player 18	15	48	167	17.2	-1.2	10.7	50	167	17.9	-0.8	19.8
Player 19	16	56.4	173	18.8	-0.7	23.9	56.4	173	18.8	-0.7	23.9
Player 20	15	52.1	170	18	-0.8	21.5	52	170	18	-0.8	20.9
Player 21	16	52	168	18.4	-0.9	18.1	54	168	19.1	-0.6	28.1
Player 22	16	73.4	177	23.4	0.8	80	70	177	22.3	0.6	71.6
Player 23	15	55.6	170	19.2	-0.2	40.5	55.6	170	19.2	-0.2	40.5
Player 24	15	53.1	160	20.7	0.3	62.2	53.5	160	20.9	0.4	64.1

Player 25	15	48.6	165	17.9	-0.9	18.7	50	165	18.4	-0.6	26.4
Player 26	16	67	159	26.5	1.5	93.1	63	159	24.9	1.9	88.3
Player 27	15	49	161	18.9	-0.4	35.2	49	161	18.9	-0,4	35.2
Player 28	15	56	161	21.6	0.6	71.6	54	161	20.8	0.3	63.3
Player 29	15	52	163	19.6	-0,1	45.6	51	163	19.2	-0,3	39,7
Player 30	16	70.1	179	21.9	0.4	67	69	179	21.5	0.3	62.9
Mean	16	60.9	172.2	20.3	-0.5	67	60.1	172.2	20.3	-0.5	51.0
SD	0.74	10.8	8.8	2.3	0.6	16.3	11.1	8.8	2.0	1	26.8

A detailed description of Gacon Test results pre and post-intermittent training protocol in G1, interval training protocol in G2, steady state training protocol in G3 is shown in **Table 3, 4, 5.**

Table 3. *Gacon Test results pre and post intermittent training protocol in G1*

PLAYERS (G1)	Pre			Post		
	Fraction speed	Fraction distance	VO2max	Fraction speed	Fraction distance	VO2max
Player 1	16	200	48	16.5	206	50
Player 2	16	200	48	17	212	51
Player 3	16	200	48	19	237	57
Player 4	17.5	218	53	19.5	243	59
Player 5	17.5	218	53	18.5	231	56
Player 6	16	200	48	18	225	54
Player 7	18.5	231	56	19.5	243	59
Player 8	17.5	218	53	18	225	54
Player 9	17.5	218	53	19.5	243	59
Player 10	17	212	51	19.5	243	59
Mean	16.95	211.5	51.1	18.5	230.8	55.8
SD	0.89	10.38	2.77	1.10	12.92	3.24

Table 4. *Gacon Test results pre and post interval training protocol in G2*

PLAYERS (G2)	Pre			Post		
	Fraction speed	Fraction distance	VO2max	Fraction speed	Fraction distance	VO2max
Player 11	17	212	51	19.5	243	59
Player 12	17.5	218	53	19.5	243	59
Player 13	16	200	48	17.5	218	53
Player 14	16	200	48	16	200	48
Player 15	17	212	51	17.5	218	53
Player 16	17.5	218	53	19	237	57
Player 17	17	212	51	19.5	243	59
Player 18	17	212	51	18	225	54
Player 19	16	200	48	16.5	206	50
Player 20	17.5	218	53	18.5	231	56
Mean	16.85	210.2	50.7	18.15	226.4	54.8
SD	0.62	7.50	2.05	1.27	15.69	3.88

Table 5. *Gacon Test results pre and post steady state training protocol in G3*

Players (G3)	Pre			Post		
	Fraction speed	Fraction distance	VO2max	Fraction speed	Fraction distance	VO2max
Player 21	16	200	48	17.5	218	53
Player 22	17	212	51	17.5	218	53
Player 23	16	200	48	17.5	218	53
Player 24	17.5	218	53	18	225	54
Player 25	17.5	218	53	18.5	231	56
Player 26	16	200	48	17	212	51
Player 27	18.5	231	56	19	237	57
Player 28	16	200	48	16.5	206	50
Player 29	17	212	51	17.5	218	53
Player 30	17	212	51	18	225	54
Mean	16.85	210.3	50.7	17.7	220.8	53.4
SD	0.85	10.43	2.75	0.71	9.00	2.06

A significant difference ($p<0.05$) between pre and post all of the three training protocols on VO_2max is shown in **Table 6.**

Table 6. *T test for paired dependent samples of G1 G2 and G3*

Paired Samples Test									
Mean		Paired Differences					t	df	Sig. (2-tailed)
		Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
				Lower	Upper				
G1	Pre - Post	-4.70000	2.66875	.84393	-6.60911	-2.79089	-5.569	9	.000
G2	Pre - Post	-4.100	2.64365	.83600	-5.99115	-2.20885	-4.904	9	.001
G3	Pre - Post	-2.70000	1.41814	.44845	-3.71447	-1.68553	-6.021	9	.000

No significant interaction ($p>0.05$) is found between group and time as shown in **Table 7**. There is only a significant effect of time, so all programs were equally effective.

Table 7. *3X2 ANOVA*

	G1 (n=10)		G2 (n=10)		G3 (n=10)		Moment x group interaction	
Variable	p	d (95% CIs)	p	d (95% CIs)	p	d (95% CIs)	p	d (95% CIs)
Fraction speed	0.001	0.78 (0.33; 0.87)	0.001	0.71 (0.22; 0.84)	0.001	0.82 (0.43; 0.90)	0.121	0.14 (0.01; 0.34)
Fraction distance	0.001	0.78 (0.34; 0.87)	0.001	0.72 (0.23; 0.84)	0.001	0.83 (0.45; 0.90)	0.112	0.15 (0.06; 0.35)
VO2max	0.001	0.77 (0.32; 0.87)	0.001	0.72 (0.24; 0.84)	0.001	0.80 (0.38; 0.88)	0.160	0.12 (0.10; 0.32)

Discussion

Interval training, intermittent training and steady state training have proven to be effective methodologies for improving aerobic capacity, and therefore VO_2max. . There were no differences between the groups and time, so they all carried the same results. This means that both state training, interval training and intermittent training have been equally effective in improving the aerobic capacity of players. It was not the same with regard to BMI, the results of which were not statistically significant, although there were an improvement in physical condition. In detecting the anthropometric characteristics both pre and post training, only one player was overweight, while all the others fall within the normal weight range. Assessment

of body composition is central to player development, as there is a close correlation between strength, speed, explosiveness, and lean mass. However, it would be necessary to see the effects of long-term training and try to take care of the diet.

The results obtained from this study regarding the effectiveness of the three methodologies in youth football were consistent with those of two other studies (Cvetković, et al., 2018; Faude et al., 2014). In the first study, the authors concluded that intermittent training allowed significant improvements in multiple measures of muscle and cardiorespiratory fitness after 12 weeks of training in overweight and obese male children. In Faude's study (2014), however, the authors showed that four weeks of in-season endurance training had led to significant improvements in stamina. Significant effects were observed in individual anaerobic threshold, peak heart rate, and CMJ, with no significant intergroup interaction. In the study conducted by Rago et al., (2017) the collected data subjected to a statistical study showed improvements in the physical performance of different athletes thanks to the use of the periodization method integrated in high intensity intermittent training. Foster et al., (2015) finally compared high intensity interval training protocols with steady-state exercise and concluded that HIIT protocols were not superior to conventional training.

As far as interval training is concerned, the studies by Laursen & Jenkins (2002) are important. It appears that, for already trained athletes, improvements in endurance performance can only be achieved through high intensity interval training. Research examining changes in muscle enzyme activity in highly trained athletes following HIIT revealed no changes in oxidative or glycolytic enzyme activity, despite significant improvements in endurance performance. Instead, an increase in the buffering capacity of skeletal muscle may be a mechanism responsible for an improvement in endurance performance. Swedish physiologist Per Olof Astrand and his disciple Irma Ryhming (later Irma Astrand) are also mentioned as being responsible for founding the initial physiology of interval training. In 1967, Astrand and his Swedish colleague Bengt Saltin published data on the maximum oxygen consumption of several athletes using the interval training methodology, publishing the highest oxygen consumption value recorded so far in a runner: 82 ml / kg / min.

Finally, as regards the studies on steady state training we can refer to Venables and Jeukendrup (2008). The two researchers hypothesized that the steady state performed at a specific constant intensity such as to maximize the expenditure of lipids, could lead to a greater oxidation of fats and a greater improvement in insulin sensitivity compared to an Interval training program, on subjects who followed a equicaloric diet (i.e. with a balanced calorie intake). Specifically, it was found that fat oxidation was increased by 44% after Steady State but not after Interval training, while insulin sensitivity was increased by 27% after Steady State. These changes occurred despite no changes in body weight, BMI, waist / hip ratio (WHR), body fat percentage, and VO_2max were detected. The researchers concluded that Steady State Training can cause a higher rate of lipid oxidation by increasing the contribution of fat as an energy substrate during exercise and can significantly increase insulin sensitivity. In conclusion, all three types of training bring significant improvements in terms of VO_2max, but not significant in relation to BMI.

Conclusion

The results of this study showed us that 12 training weeks of intermittent training, steady state training and interval training had equally improved VO_2max in a soccer team, but not BMI. This study allowed us to recommend all three types of training methodologies to improve aerobic capacity. However, you would need to see the effects of long-term training to see significant improvements in BMI. This study demonstrated the equal effectiveness of the three most popular training methodologies in soccer. Coaches are encouraged to alternate these three training methodologies appropriately, in their team's annual athletic training program.

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