ORIGINAL ARTICLE

Effects of high-intensity interval training on aerobic fitness in elite Serbian soccer players

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Abstract

The aim of this paper was to determine whether the high-intensity interval training (HIIT) training can improve aerobic fitness in regional-level soccer players. Billat method (30-30s and 15-15s; 6-12 min) was used twice a week for 8 weeks during a season. Twenty-Three National-level soccer team players, (years=25±8, height=183.28±5.93, weight=75.28±5.9), were recruited for this study. Pre- and post-experimental period, maximum oxygen uptake was measured thru pseudo-ramp test on treadmill until volitional fatigue. Obtained results showed improvement in aerobic fitness for post- vs premeasurement (initial measurement = 51.92±3.40, final measurement = 54.87±2.61, $p<.001$). It is likely that specific high intensity interval training is viable method for aerobic fitness improvements in national-level soccer players when conducted during season.

Keywords Pseudo-ramp test • VO_2max • High intensity interval

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Introduction

Technical and tactical aspects could be determined with players fitness-level, and because of that they are extremely important. It is generally accepted that players aren't able to show their skills on the field if they are not sufficiently conditioned. Modern soccer is energy demanding sport with the ability of players to repeat high-intensity actions during the game likely being of paramount importance for success (Helgerud et al., 2001).

Research suggests that the aerobic system is the main source of energy in soccer, watching the duration of work and rest. VO_2max represents the upper limit that determines the ability of an organism to consume oxygen, is expressed in millimetres per kilogram of body weight per minute (ml/kg/min) as a relative value or in litres per minute (l/min) as an absolute value. One of the reason why the match course could be changed are higher levels of aerobic ability, and that lead to delayed fatigue and provide faster recovery during the short periods of lower intensity during the game (Helgerud et al., 2001). When the teams are equal in terms of technical and tactical capabilities, fitness level will determine final outcome of the game. Consequently, aerobic fitness testing are regularly done in soccer players, usually thru pseudo-ramp test protocols on treadmill and with obtain value considered to be the gold standard in the measurement of aerobic abilities (Aziz et al., 2005).

In a modern soccer, VO_2max vary between 50 and 75ml/kg/min. Research suggests that lower ranked clubs have lower VO_2max values when compared with better ranked clubs. Physiological

ability, VO_2max, is not a sensible measure of competence in soccer and it has been stated that players who have VO_2max over 60ml/kg/min one day could be elite soccer players (Tønnessen et al., 2012). The sprints number, periods with the ball, and covered distance during the soccer match have positive effects with aerobic fitness improvements (Howard & Stavrianes, 2017). The relative contribution of aerobic metabolism could be increased if repeated high-intensity exercise has insufficient recovery phase, and that movement pattern is specific for field-based team sport. The ability to buffer H^+ is important attribute for maintaining performance in case the players have brief, repeated sprints. If we enhance muscle buffer capacity and aerobic fitness we could have positive effects on RSA. The HIIT training with benefits of anaerobic training is possible alternative to standard endurance conditioning. (Howard & Stavrianes, 2017). RSA and velocity at which VO_2max is attained have strong correlation (da Silva et al., 2010). HIIT is good training plan for improving aerobic fitness, without side effects on strength, power and sprint performance. In enhancing aerobic fitness and football-specific endurance using aerobic interval training, both exercises (specific or generic) is equally effective. Effective training strategy for developing aerobic fitness in football players can be considered with high intensity aerobic interval training (Ferrari et al, 2008).

Taken altogether, it seems that interval training can be considered viable method for aerobic fitness development in different levels of soccer players. However, data of its effectiveness in sub elite players are scarce and conflicting. The aim of this research is evaluating the effects of HIIT. Also, we wanted to investigate if there were some interval training-induced positional role differences.

Method

The research included a male soccer team competing in the first league competition in Serbia, ages 17 to 33, without medical disturbances. We tested 23 players (years=25±8, height=183.28±5.93, weight=75.28±5.9) divided into groups depending on the role in the team, 9 defense players (8 defenders and 1 goalkeeper) and 14 players (9 midfielders and 5 offensive players). Testing was carried out in laboratory settings in two-time points separated with 8 weeks.

The motorized treadmill provided the most suitable form for testing the VO_2max for the soccer players, while the results on the bicycle ergometer would be 10 to 15% lower. Incremental pseudo-ramp test protocol was conducted by motorized treadmill (13620 Treadmill, VacuMed, California, USA), which was computer-driven. Heart rate was continuously monitored during the test (Polar S-810, Polar Electro Oy, Finland). We were using automated gas analysis system, a 2-way valve used to collect and analyze expired air (VistaVo2Lab, VacuMed, California, USA). The calibration of gas analyzer and volume transducer were performed according to manufacturer's specification. Following warm up (3 min of running at 3.8 mph), incremental protocol (starting at 7mph/h with 0.6mph/min increment) was applied until volitional fatigue. The attaining VO_2max criteria are volitional exhaustion, attainment of at least 90% of the predicted HRmax age (220-age); RER equal to or greater than 1.10; and VO_2 leveled off even with an increase in intensity. Experimental treatment included the use of a Billat method to increase VO_2max twice weekly for a duration of 8 weeks. Combined Billat method 30s-30s and 15s-15s 6 to 12 minutes. The 30s-30s Billat method is performed by responding for 30 seconds to 100% of vVO_2max (vVO_2max is the minimum running speed that produces VO_2max, i.e., the ability of the muscular system to use oxygen at the highest possible level) and 30 seconds of active recovery at 50% vVO_2max. While the 15s-15s method is carried out, the respondent runs 15s to 110% of the vVO_2max, and during the active recovery it runs to 70% of the vVO_2max (this method is more intense). In the first two weeks the Billat method 30s-30s was applied twice a week. Then, on the third and fourth week, the Billat method 30s-30s and 15s-15s were combined (once a week). Fifth and sixth weeks the Billat method 15s-15s was applied, while 15s-15s Billat was used for the last two weeks, but only once a week.

Whether there are statistically significant differences between the initial and final measurement of VO_2max was compared with the One-Sample t-Test.

Results

By statistical analysis of the testing results obtained on a sample of 23 respondents, namely 9 defense players (8 defenders and 1 goalkeeper) and 14 players of attack (9 midfielders and 5 offensive players), we

found statistically significant differences, using One-Sample t-Test, between the initial and final measurements, (Table 1.).

Table 1. Results of One-Sample T Test

	Initial result	Final result	Final-initial result	
Variable	mean±SD	mean±SD	mean±SD	p
VO_2max	51.92±3.40	54.87 ± 2.61	2.95 ± 1.31	.000

Legend: SD – standard deviation; p – significance

Discussion

Obtained results showed improvement in aerobic fitness for post- vs premeasurement (initial measurement = 51.92±3.40, final measurement = 54.87±2.61, p<.001). Considering positional differences, no statistical difference was found. It is likely that specific high intensity interval training is viable method for aerobic fitness improvements in national-level soccer players when conducted during season.

The previous research has shown that proven efficient, in stimulating the oxygen consumption, is that short interval-training of 15s-15s at 90-80 and 100-70% of vVO_2max, to its long-distance runners (healthy middle-aged) has implemented long slow distance-training (Billat et al., 2001). The continuous training at 70% vVO_2max produced a lesser increase in VO_2max than interval training with repetitions of 30 seconds work at 100% vVO_2max, separated by 30 seconds of rest. The active recovery of 30 second rest (50% vVO_2max), gave us a chance to stayed at VO_2max even during the recovery period, from the fifth to each next repetition of a 30-second run at vVO_2max, and a 30-second run at 50% of a required velocity, reported by Billat in a 30–30-second, short interval training. Some players keep it VO_2max for 10 minutes (during 83% of total time run at vVO_2max) at this type of training. The average value of blood lactate was 7.4 ± 1.8 mmol/l. Interval training performed at velocities close to the velocity associated with VO_2max (vVO_2max) may maximize the improvement in VO_2max, as well as mitochondrial density result improvements. Pauses between the intervals of hard work (our proposal is the active rather than passive) will stimulate lactate removal whilst remaining close to the maximal blood lactate steady state and also elicit and maintain VO_2max (Billat, 2001).

Studies on soccer players have shown that training (> 85% HR(max)) during 8 to 12 wk, could have benefits at VO_2max enhancement (5% to 11%), then better running economy (3% to 7%), and lower blood lactate afflux underway submaximal exercise. There is also an improvement in the yo-yo intermittent recovery (YYIR) test performance (13%). We could have similar adaptation during the high intensity training with SSG. A positive influence on a soccer-specific endurance we have from speed-endurance training, which proved with improvements in the YYIR test (22% to 28%) and the possibility to perform RSA (approximately 2%). The young soccer players, thirty of them, (14-15 years) were randomly assigned to one of groups. We had short-sprint and long-sprint training groups. They completed similar fitness tests (2 sets) before starting and after 7 weeks training periods. Each of 2 training programs contained SST (4-6 sets of 4 × 50-m all-out sprint) and LST (4-6 sets of 200-m run at 85% of maximum speed), held 3 times per week. Training programs significant improve VO_2max (predicted from the 20-m shuttle run, $p < 0.01$), with no between-group difference ($p = 0.14$) (Meckel et al., 2012). (Andrea et al., 2012) were hypothesized that HIIT and traditional endurance training could be comparable for improving aerobic capacity. That is conclusion after a 5-week training period at female college soccer players. HIIT group performed VO_2max and Yo-Yo intermittent Recovery 1 test. The assignment of sprint training group was to achieve 5 maximal sprint efforts with stimulus during 30 seconds and active recovery in duration of 4.5 minutes, twice weekly. The endurance training group perform 40-min run at 80% of VO_2max, two times per week, before and after that intervention. The result of training program was significant in team VO_2max values (50.66±3.52 ml·kg-1 ·min-1 vs. 52.71±3.24 ml·kg-1 ·min-1 respectively, p=0.002), with no

significant differences between groups for the pre- (p=0.493) and post- tests (p=0.362) within the training program results. The average VO_2max improved by 2.36 ml·kg-1 ·min-1 (4.73%) for sprint training and 1.66 ml·kg-1 ·min-1 (3.42%) for endurance training. In our research we have non-optimal aerobic capabilities, when comparing to other soccer players across Europe like in (McMillan et al., 2005) study where youth soccer players (11 of them) with average age of 16.9 (±0.4) years accomplish HIIT sessions two times per week, as an additional training session during 10 weeks period. The specific aerobic training contained of periods (4 sets of 4 min work) dribbling a soccer ball around a track, which is specially designed, at 90-95% of maximal heart frequency, during a 3-min recovery of jogging at 70% of maximal heart frequency among intervals. We have average VO_2max significantly improved from 63.4 (±5.6) to 69.8 (±6.6) ml·kg-1min-1, or 183.3 (±13.2) to 201.5 (±16.2) ml·kg(-0.75) min-1 ($p<0.001$). (Chamari et al., 2005) tested soccer players (18 male and 14 years old) both in the laboratory while using the Hoff test during the time (before and afterwards 8 weeks) of soccer training. The covered distance and oxygen uptake significantly correlated in the Hoff test, and meliorate within 9.6% throughout the training period (8 weeks). During that time maximum oxygen uptake and running economy meliorate within 12 and 10%, respectively. The limitation of this study is small sample size which preclude us from generalization of obtained data. Furthermore, the absence of control group significantly hinders study results findings, as we cannot state the obtained results are the result of implementing interval training alone.

In conclusion, we can state that 8 weeks of high intensity interval training likely produce significant improvements in regional level soccer players and that it can be proposed as efficient training modality for improving aerobic fitness in soccer players during competitive season.

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