Journal of Physical Education and Sport ® (JPES), Vol. 21 (3), Art 192, pp. 1510 - 1519, May 2021
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Effect of small-sided games on the biochemical profile of elite soccer players

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Published online: May 31, 2021
(Accepted for publication May 15, 2021)
DOI:10.7752/jpes.2021.03192

Abstract
In soccer players are exposed to intensive physiological stress during training, which promote changes in biochemical markers that practitioners have to investigate in order to determine the internal training load. In this sense soccer training mainly due to eccentric actions cause biochemical disturbances that increase inflammation and muscle damages which may reduce performance. A popular training method which is widely used by soccer practitioners to optimize training time by replicating games' demands, is Small Sided Games (SSGs). Thus, the aim of this study was to examine lipid, enzyme, and hormone changes caused by Small Sided Games (SSGs). The sample consisted of eight U20 elite soccer players (aged 18.3 ± 1 year) of the Greek Super League, who participated in six SSG's (4 vs 4 + 2 GK) each lasting 4 min with rest of 3 min, on an artificial field with dimensions of 30x20m. Blood samples were taken by accredited personnel before and after the six SSGs to determine the change of the lipid profile, enzymes, and hormones. The Total Cholesterol (T-C), High density lipoprotein cholesterol (HDL-C), Low density lipoprotein cholesterol (LDL-C), Triglycerides (TG), Lipid, gamma-glutamyltransferase (γ-GT), Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Plasma Creatine Kinase (CK), Isoenzyme of creatine kinase (CK-MB), Lactate dehydrogenase (LDH), Cortisol, Testosterone were measured. The Wilcoxon Test (Z) and the Effect Size (r) were used to compare the repeated measures of the variables (pre and post), while the Pearson correlation (r) was used to test the correlation between them. The results showed that T-C, HDL-C, T-C/HDL-C (ratio), LDL-C, and TG were non-significantly reduced after the interventional SSGs. On the contrary, CK, CK-MB, LDH and Testosterone significantly reduced due to the interventional SSGs, whereas Cortisol significantly increased. Overall, the results showed that SSGs with high intensity cause specific metabolic effects of the enzyme and hormonal profile on male players. Understanding the importance of the impact of lipid parameters for the performance and health of the players can help coaches and to better prepare high-intensity training sessions.
Keywords: lipid, enzyme profile, hormonal profile, performance, monitoring

Introduction

Soccer is an intermittent sport involving periods of high-intensity actions (e.g., changes of direction, agility, sprints, jumps, turns, accelerations, decelerations), interspersed with low-intensity actions (e.g., walking, jogging), as well as tactical and technical components (Bangsbo, 1994; Sparkes, et al., 2018). In this sense, a popular training method which is widely used by soccer practitioners to optimize training time by replicating games' demands, is Small Sided Games (SSGs) (Casamichana et al., 2012; Hill-Haas et al., 2011). SSGs are smaller and adjusted formats of soccer game which are implemented into training and mainly combine physiological exercise and specific game situations such as offensive or defensive numerical superiority/inferiority, designed according to the needs and the focus of the training session (Costa et al., 2009; Mascarin, et al., 2018). Depending on the SSGs' format, the physiological and physical demands may vary. The demanding nature of this type of exercises has been reported to lead to high physiological responses and mechanical load (Lacome et al., 2018; Sgrò et al., 2018). The nature of the SSGs which essentially determine the level of the demands depends on the conditions and rules of the SSGs such as the field size, the duration, and the rest time (Clemente et al., 2020; Sarmento et al., 2018).

Regardless the nature of high-intensity exercises; this type of exercises is known to generate several metabolic changes in players (Cicero et al., 2016; López-Fernández et al., 2017). Consequently, this can cause hematological, biochemical, and hormonal variations, as well as oxidative stress and muscle damages, mainly due to eccentric muscle contractions (Bangsbo et al., 2006; Gravina et al., 2011). Regarding biochemical markers, it has been found that creatine kinase (CK) and Lactate Dehydrogenase (LDH) the most popular enzymes that provide indirect support for muscle microtrauma are related with micro-injuries and muscle inflammation, causing a delayed increase in inflammatory indexes within the bloodstream. In particular, CK and LDH increases are probably explained by increments of intramuscular permeability of plasma membrane and/or

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vasculature (Freire et al., 2020; Silva et al., 2013). Similarly, alanine aminotransferase (ALT) and aminotransferase (AST) enzymes which are widely used in diagnosis of skeletal muscle damages due to exercise, consist indexes of tissue damage and cellular necrosis within muscles (Nie et al., 2011). As far as hormones and lipids, which play an important role in biological functions, induce responses in tissues and include the usage of triglycerides during activity on energy production and fat storage. In addition increased plasma cholesterol concentrations have been implicated in the development of fatigue and injuries (Manna et al., 2010).

Therefore, the use of different high-intensity training regimes can potentially lead to performance decreases due to their demanding nature for the players (Hourcade et al., 2019; Sparkes et al., 2018). Most studies examining the effects of SSGs has examined a limited number of physiological elements in an attempt to discover biomarkers of performance (Bangsbo et al., 2007; Cicero et al., 2016; Rietjens et al., 2005). However very limited studies have focused on acute biochemical changes due to specific SSGs formats in youth populations (Alashti et al., 2020; Carling et al., 2012; LQT Aquino et al., 2016). Biochemical monitoring is a useful tool for practitioners to design effective training programs, in accordance with load, stress, fatigue, and possible injuries management, to improve performance (McCall et al., 2015; Rodrigues de Araujo et al., 2018).

Soccer training with different formats of SSGs includes both aerobic and anaerobic systems in which energy is produced by oxidizing either carbohydrate or lipids (Brooks, 2011; Kiens, 2006). Exercises with longer duration are typically require more aerobic contribution and hence they are used to enhance aerobic capacity. However, this can also be achieved via shorter training lasting from 1 to 4 minutes. Despite this type of exercises are mainly considered anaerobic they can also improve the aerobic capacity of athletes (Hackney, 2016). During exercise, two classes of biocatalysts are very important for players' organism functions, the hormones, and the enzymes. Enzymes are responsible to accelerate the chemical reactions and the metabolism of the body, while they are also essential for muscle and nerve functions, as well as for respiration (Ringe & Petsko, 2008). In long duration activities, they are also responsible to hydrolyze lipids into free fatty acids, glycerol and free cholesterol which can be converted into energy by oxidation. In addition, hormones, are responsible not only for increasing blood glucose, force, energy production, and muscle contraction rate but also their functions are related with the concentration and activity of the enzymes which are the prime cellular catalysts (MacLaren & Morton, 2011). In short, the interaction of these biocatalysts permits the chemical reactions of the organism during exercise (White, 1960). More specifically, training increases activity of the enzymes leading to improved aerobic and anaerobic capacities (Hackney, 2016). However, the effect of training on the activity of enzymes on anaerobic metabolism is not clear and depends on several factors such as the duration and the intensity of exercise, the playing status, and the age of players (MacLaren & Morton, 2011). For instance, although the maximal activity of CK and glycolytic enzymes was increased after training for recreational athletes (Roberts, Billeter, & Howald, 1982), studies examining trained athletes have not indicated changes (Bangsbo, Gunnarsson, Wendell, Nybo, & Thomassen, 2009; Iaia et al., 2008).

Thus, by exposing players to intensive physiological stress during training, SSGs promote changes in biomarkers that need to be further investigated by sport scientists and practitioners to determine the appropriate internal training load (Boullosa et al., 2013; Coelho et al., 2013). In this sense, recent studies have indicated that soccer training, mainly due to eccentric actions cause biochemical disturbances that increase inflammation and muscle damages which may reduce performance (Malone et al., 2018; Meister et al., 2013).

In addition, the measurement of biochemical biomarkers could be used to evaluate fatigue and recovery from soccer exercise. (Nédélec et al., 2012). Therefore, analysis of SSGs effects could contribute to the development of more specific training sessions with less stress by identifying possible negative effects on muscular system (LQT Aquino et al., 2016). Therefore, the aim of the current study was to identify the changes in biochemical markers caused by SSGs' training to professional soccer players. The researchers hypothesized that the elaboration of 4 vs 4 + 2 GK SSGs with the specific format and rules might simulate the workload demands of a competitive game.

Materials and Methods

Sample

A total of eight professional male soccer players from the U20 age category of the Greek Super League participated in this study (age: 18.4 ± 1 years; height: 174 ± 3cm; body mass: 68.9 ± 2 kg and body fat: 9.46 ± 1%). One week prior to the measurements and during the study, participants received a balanced diet as outlined by Souglis 37 with 15% of the energy intake from protein, 25-30% from fat, and 50-60% from carbohydrates. On the match-day, players consumed a meal rich in carbohydrates (approximately 60-65% of total energy intake) three hours before the game.

The players were healthy non-smokers and performed the routine medical examination (chest X-ray, blood pressure assessment, and electrocardiogram) which confirmed that none of the participants had any pathological conditions. All procedures were fully approved by the Ethics Committee of the University and were conducted according to the Declaration of Helsinki. All the players were informed about the research protocol, experimental procedures, and possible risks and signed a written consent for their participation to the study.

Procedures

Players took part in five training sessions, each lasting 60-80min and one competitive game per week. Each training session included speed, agility, strength, power, technical and tactical exercises, and small sided games. The three-day period prior to the measurements, players followed the regular training routine, while avoiding high-intensity exercises (i.e., SSGs with low number of players). Instead, they trained in 8 vs 8 SSGs in larger areas with average heart rate ranging from 65 to 75% of maximal heart rate. In addition, the day before the measurements the players did not train at all.

Anthropometric Measurements

Initially, the anthropometric measurements of the participants were conducted in the laboratory. More specifically, standing height and weight were assessed by Seca Scales, to the nearest 0.5 centimeters and 0.1 kilograms respectively (Stadiometer and Beam balance 710; Seca; Birmingham; United Kingdom), while participants were wearing minimal clothing and no shoes. Their body fat was estimated, using the seven-skinfold method, by a skinfold caliper (Harpenden Skinfold Caliper; Baty International; West Sussex; United Kingdom). Environmental temperature and the relative humidity were between 16-20oC and 40-60% respectively.

Blood Samples and Analyses

All blood collections were performed by accredited personnel, following all asepsis and hygiene care. Two blood samples (5 cc each) were collected during the competitive period. The first sample was taken in the morning of a competition day, after 12 hours of fasting, and the second blood sample was taken immediately after the end of the experiment. During blood sampling, participants were seated, and blood was drawn from the basilic vein. Blood samples were placed in testing vials without blood thinning agents and were processed to get blood serum. The blood centrifugation was accomplished for 10min in 2500rpm/min, within 1h after blood sampling. The serum samples were preserved in -70oC until the processing.

Triglycerides (TG) and total cholesterol (T-C) levels were measured by a semi-automatic analyzer 505 with the enzymatic colorimetric method (PAP kit 2624 and 2486, respectively, by BIOSIS). High density lipoprotein cholesterol (HDL-C) was measured by the tungsten phosphate method (kit 2808, BIOSIS), while low density lipoprotein cholesterol (LDL-C) was measured by the FRIENWALD analyzer. Plasma creatine kinase (CK), gamma-glutamyltransferase (γ-GT), alanine aminotransferase (ALT), and aspartate aminotransferase (AST), creatine kinase-MB isoenzyme (CK-MB), lactate dehydrogenase (LDH) activity were determined in serum spectrophotometrically (Hitachi 917 analyzer; Roche Diagnostics GmbH) using commercially available assays (Sigma-Aldrich, St. Louis, MO, USA). Cortisol and Testosterone were analyzed using a semi-automatic analyzer (Biosystems BTS310) and the appropriate controls (Precinorm and Precipath, Boehrigher Mannheim).

Small Sided Games

Prior to the SSGs all the players performed a 15 min routine warm-up without ball (e.g., jogging, sprinting, dynamic stretching) as well as a 10min warm-up with ball (e.g., passing, dribbling). The coaches divided the players into two evenly equitable teams to preserve the competitiveness of the game. The evaluated protocol included six 4 vs 4 SSGs + 2 GKs each lasting 4min, with 3min of passive rest intervals between the sets. The SSGs took place in a pitch with artificial turf and dimensions of 30x20m (30m length and 20m wide). The SSGs were performed with two coaches standing outside of the playing area to constantly supply with new balls when necessary and to encourage the players to keep a high intensity during the games.

Statistical Analysis

Data are reported as Means (M) and Standard Deviations (SD). The statistical analysis was performed using Statistical Package for Social Sciences software for Windows (version 22.0; SPSS, IBM, Chicago, IL, USA). The Wilcoxon test (Z) and the Effect Size (r) were used to compare and estimate the magnitudes of the pre- and post- training measurements. According to Cohen (1988) and Carson (2012) the effect size was interpreted as small (< 0.2), medium (0.5) and large (≥ 0.8). Furthermore, Pearson correlation coefficient (r) was applied to calculate the relationship between the variables. In all cases, level of significance was preset at 5% ($p < .05$).

Results

Comparisons of pre- and post- exercise biochemical variables and descriptive statistics for the main variables are presented in Table 1. The results showed that after the six SSGs the lipid profile of soccer players was not significantly affected ($p > .10$). On the contrary, the majority of both the enzymes and the hormones were significantly changed ($p < .05$). The effect sizes of the vast majority of the measures demonstrated medium to large magnitude with r values over 0.5. More specifically, the Wilcoxon tests indicated that post- training measurements of the following enzymes, i.e., CK ($Z= -2.380$, $p < .05$), CK-MB ($Z= -2.539$, $p < .01$), LDH ($Z= -2.10$, $p < .05$), were significantly higher than pre- training measurement. The Wilcoxon tests also indicated that post- training measurement of the following hormones, i.e., Cortisol ($Z= -2.527$, $p < .01$) was significantly higher than pre- training measurement, while Testosterone ($Z= -2.521$, $p < .01$) was significantly lower than pre-training measurement.

Table 1. Examined variables in the soccer players at pre-, post- SSGs (mean ± s, Wilcoxon-test (Z), sig. and Effect size (r)).

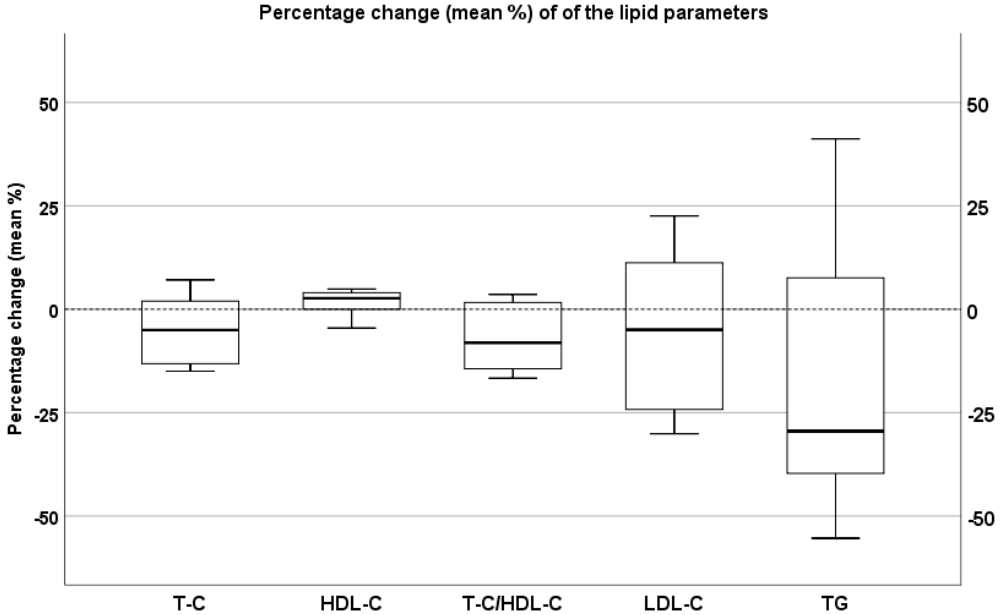
	Variables	Measurements						
		Pre		Post		Wilcoxon Test (Z)	Exact Sig. p	Effect Size (r)
		Mean	Sd	Mean	Sd			
Lipids	T-C (mg/dl=0.01 kg/m^3)	171.88	21,49	162.50	18.46	-1.40	0.20	0.49
	HDL-C (mg/dl=0.01 kg/m^3)	63.13	12.19	64.13	12.32	-1.166	0.28	0.41
	T-C/HDL-C (ratio)	2.78	0.41	2.60	0.53	-1.706	0.11	0.60
	LDL-C (mg/dl=0.01 kg/m^3)	92.00	18.91	86.25	20.83	-0.840	0.46	0.30
	TG (mg/dl=0.01 kg/m^3)	83.63	37.21	60.75	17.55	-1.680	0.11	0.59
Enzymes	CK (U/L)	273.13	46.29	335.63	82.21	-2.38	0.02*	0.84
	CK-MB (U/L)	10.88	2.42	13.25	2.92	-2.539	0.01*	0.90
	γ-GT (U/L)	19.25	3.24	18.88	2.53	-0.816	0.75	0.29
	ALT (U/L)	40.00	4.54	39.25	3.88	-1.473	0.25	0.52
	AST (U/L)	32.75	9.65	34.63	9.83	-2.047	0.06	0.72
	LDH (U/L)	257.13	39.92	281.75	47.59	-2.1	0.04*	0.74
Hormones	Cortisol (μg/dl=1,0x10-5kg/m^3)	9.21	2.36	15.21	3.84	-2.527	0.01**	0.89
	Testosterone (ng/dl)	432.38	121.66	331.38	91.27	-2.521	0.01**	0.89

Notes: sig. $p < .05$ *, $p < .01$ **, $p < .001$ ***

Effect size (r): small (< 0.2), medium (0.5) and large (≥ 0.8)

Abbreviations: Total Cholesterol (T-C), High density lipoprotein cholesterol (HDL-C), TC/HDL-C (ratio), Low density lipoprotein cholesterol (LDL-C), Triglycerides (TG), Plasma Creatine Kinase (CK), Isoenzyme of creatine kinase (CK-MB), gamma-glutamyltransferase (γ-GT), Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Lactate dehydrogenase (LDH), Cortisol, Testosterone

Lipid series T-C, T-C/HDL-C, LDL-C, and TG indicated a non-significant ($p > .05$) reduction after the six SSGs of 1.51%, 6.31%, 6.25%, and 27.35% respectively. On the contrary, HDL-C non-significantly increased after the interventional SSGs for 1.58% (Figure 1).

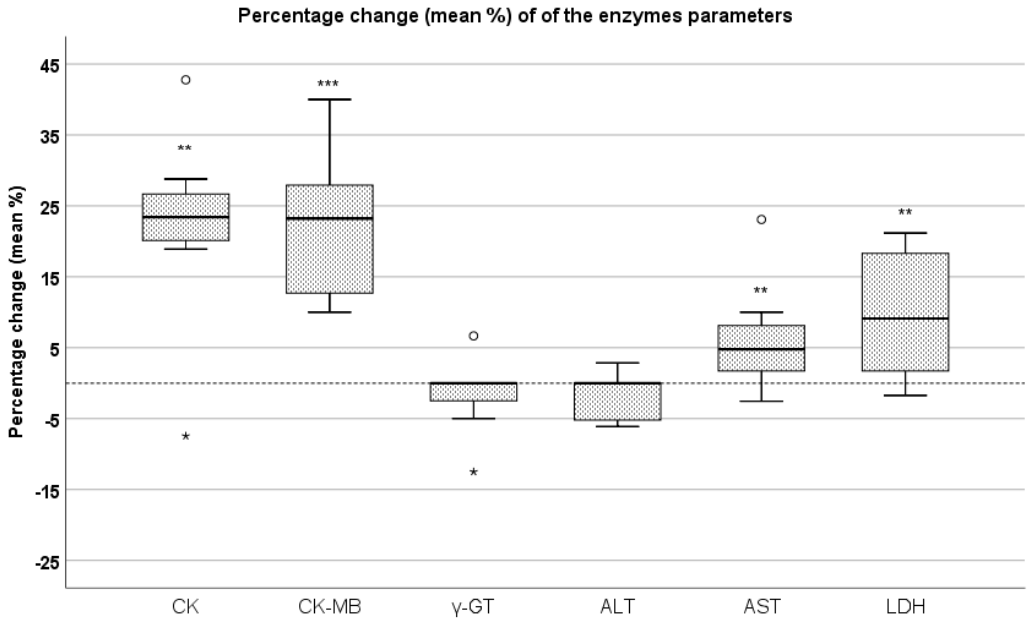


Notes: sig. $p < .05$ *, $p < .01$ **, $p < .001$ ***

Abbreviations: Total Cholesterol (T-C), High density lipoprotein cholesterol (HDL-C), TC/HDL-C (ratio), Low density lipoprotein cholesterol (LDL-C), Triglycerides (TG)

Figure 1. Percentage change (mean %) of the Lipid parameters in the soccer players at pre-, post-SSGs.

Moreover, enzymes, post- measurements CK, CK-MB and LDH significantly increased 22.88%, 21.84% and 9.58%. On the contrary, ALT, AST, and γ-GT did not show any significant changes (Figure 2).

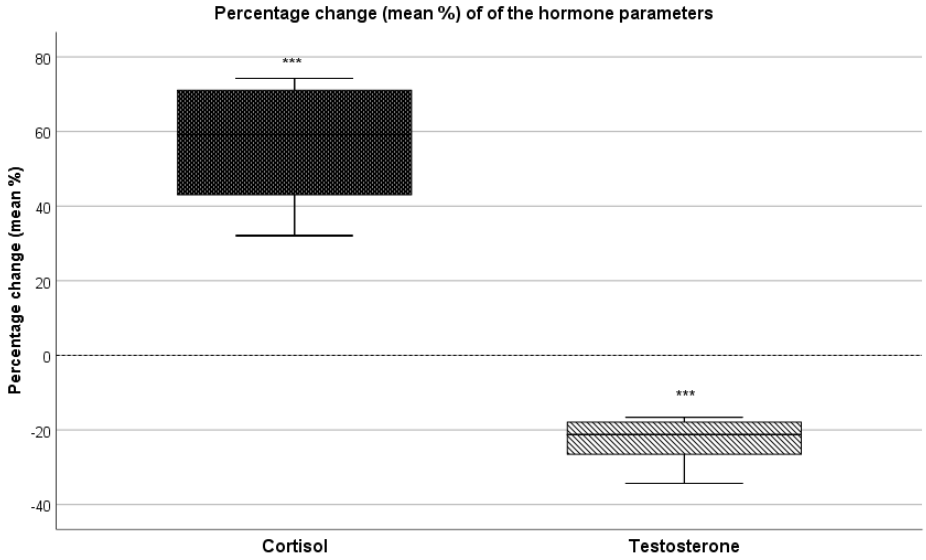


Notes: sig. $p< .05$ *, $p< .01$ **, $p< .001$ ***

Abbreviations: Plasma Creatine Kinase (CK), Isoenzyme of creatine kinase (CK-MB), gamma-glutamyltransferase (γ-GT), Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Lactate dehydrogenase (LDH)

Figure 2. Percentage change (mean %) of the parameters of the enzymes parameter.

As far as Cortisol and Testosterone changes after the experimental SSGs, the results indicated a significant increase caused by experimental SSGs of 65.13% for Cortisol and a significant reduction of 23.36% for Testosterone (Figure 3).



Notes: sig. p<.05 *, p<.01 **, p<.001 ***

Figure 3. Percentage change (mean %) of the Hormone parameters.

Table 2 shows the Pearson correlation matrix between the variables of the second measurement which revealed statistical significance ($p < .05$). In particular, the results showed a large positive relationship between T-C/HDL-C ratio and LDL-C ($r= .887$, $p = .003$), whereas a large negative relationship was observed between HDL-C and T-C/HDL-C ratio ($r = -.846$, $p = .008$). On the contrary, non-significant changes were found among the rest of the lipid variables, as well as between enzymes and hormones.

Table 2: Statistically significant correlations (Pearson *r*) in the lipid parameters immediately after playing 6X4vs4+2Gk SSGs.

Variables		R	P
HDL-C	T-C/HDL-C (ratio)	-.846**	.008
T-C/HDL-C (ratio)	LDL-C	.887**	.003

Notes: Sig.: $p< .05$ *, $p< .01$ **, $p< .001$ ***

Abbreviations: Total Cholesterol (T-C), High density lipoprotein cholesterol (HDL-C), TC/HDL-C (ratio), Low density lipoprotein cholesterol (LDL-C)

Discussion

The current study examined the effect of SSG's training on professional soccer by investigating the potential changes in biochemical markers. Considering that high-intensity exercise causes several acute physiological changes, the researchers examined the hypothesis that 4 vs 4 + 2 GK exercise induces changes in biochemical markers in U20 professional soccer players. The results partially confirmed this hypothesis in several of the variables included in the study. In particular, the intensity of the SSG training replicated the demands of a competitive game as the average heart rate of players was 89% of maximal heart rate (Sparkes et al., 2018).

Regarding the lipid profile of the players, the results showed that the current experimental approach did not significantly affect lipid markers. In this sense none of the selected variables T-C, HDL-C, ratio of TC and HDL-C, LDL-C, TG significantly changed after the practice with six 3-min 4 vs 4 + 2 GK SSGs' exercise. Although the non-significant changes, the descriptive statistics revealed that apart from HDL-C, the other lipid markers were reduced. However, previous studies have indicated that exercise causes changes in the total amount of cholesterol in the blood. It has been found that total cholesterol, low-density lipoprotein cholesterol, as well as triglycerides reduced after a period of high-intensity training, whereas high density lipoprotein cholesterol was increased (Alexiou et al., 2018). Although current findings showed non-significant changes, the trend of the results was in line with the existing findings. This finding can be explained by the short duration and the high intensity of the applied exercise. It is well documented that in order to improve the lipid profile of the players, long-duration and moderate-intensity aerobic exercise is more appropriate (Apostolidis et al., 2014; Seabra et al., 2020; Wang & Hu, 2017; Yamaner, 2010). In addition, a significant negative correlation was found between T-C/HDL-C ratio with HDL-C but a significant positive correlation between T-C/HDL-C ratio with LDL-C relationships which are supported by past literature (Lemieux et al., 2001; Millán et al., 2009) and confirm the potential role of these variables on lipid changes.

Furthermore, the results also showed increased plasma muscle enzymes (i.e., CK, CK-MB, and LDH levels), while CK and LDH were also above the normal range. In line with previous studies (Anđelković et al., 2015; Pascoal et al., 2018), these changes indicate the extensive cell muscle damage and induced functional status of muscle tissues. For instance, LDH and CK are two biochemical biomarkers frequently used to determine inflammation and muscle damages (Coppalle et al., 2019; Djaoui, Haddad, Chamari, & Dellal, 2017). Specifically, LDH is an enzyme which is related to muscle damage by catalyzing the conversion of pyruvate acid to lactate and back. It plays an important role in cellular respiration, the process by which glucose is converted into energy for cells. Furthermore, CK is an enzyme that buffers the ATP and ADP concentrations by catalyzing the transaction of high-energy phosphate between phosphocreatine and ADP (Brancaccio, Lippi, & Maffulli, 2010). CK is considered to be a biomarker for the early detection of muscle damages of soccer players (Lazarim et al., 2009). On the other hand, AST, ALT, and γ-GT which are also biomarkers of cell damage, remained stable after the experimental SSGs. In particular, AST, ALT, and γ-GT consist of enzymes released in the muscle by the liver and help the body to metabolize proteins. They usually enter in the blood stream when there is muscle damage. Previous studies have shown that ALT, AST and CPK reduced during preparation period, whereas they increased during in-season, while GGT concentrations remained unaltered after a soccer period (Gioldasis, 2016), as well as immediately after a soccer game (Devrnja & Matković, 2018; Sanchis-Gomar et al., 2015). On the other hand, following a training program which included 1 hour of weightlifting it seems that CK, LDH, AST, ALT and myoglobin increased, while ALP, GGT and bilirubin remained unchanged (Pettersson et al., 2008). Those contradicting findings might be potentially attributed either to varied intensity and duration of the exercises or different methodological approaches between the studies (Brun, Romain, & Mercier, 2011; Çiçek, 2018; Souglis et al., 2015, 2018). It is well documented that the intensity and duration of exercise increases the AST and ALT values (Turgut et al, 2017). A potential explanation for the non-significant change in these parameters may be explained by the fact that blood urea levels remained unchanged.

As far as the hormonal level changes the results indicated a significant increase of cortisol values immediately after the experimental SSGs, whereas the testosterone significantly reduced. The testosterone and cortisol ratio is a significant parameter which has been reported as a balance factor of anabolic and catabolic functions (Sparkes et al., 2018). Existing literature has highlighted a significant increase of cortisol levels after

exercise (Bekris et al., 2020; De Waal, 2017; Ispirlidis et al., 2008; Mascarin et al., 2018), while players with longer participation time showed greater increases (Bekris et al., 2020). In contrast to current findings, several studies have shown that testosterone levels are higher after exercise (Bekris et al., 2020; Ispirlidis et al., 2008; Mascarin et al., 2018). On the other hand, it has been found that cortisol did not present significant acute changes after a SSG (De Waal, 2017; Mascarin et al., 2018), while testosterone concentrations reduced after high-intensity exercise (Pimenta et al., 2012). This can be explained by the fact that training based on SSGs is less likely to produce the same hormonal responses to the stimuli as the official soccer games (De Waal, 2017; Oliveira et al., 2009). Furthermore, training status of the players may have a role in hormonal responses to exercise. Elite level players train systematically and consequently they are well adapted on this type of training (Moreira et al., 2009). Therefore, hormonal changes may require further analysis to determine their contribution with regards to type of training. A large individual variability which highlights the need of individualization when analyzing hormonal responses to SSG training (Thorpe & Sunderland, 2012).

Conclusion

The biochemical responses to SSGs exercise are extremely intricate as they are affected by the format of the games (e.g., intensity, duration, dimensions, number of players, recovery time between games) and the individual characteristics of the players (e.g., stress, training status, level of play, playing position). The results of the study showed that a training session which includes six 4 vs 4 + 2 GK SSGs, each lasting 4min, with 3min of passive rest, with dimensions of 30X20, cause acute changes in CK and CK-MB and LDH levels, as well as in cortisol and testosterone levels. Therefore, this type of exercise is suggested to be an appropriate training method to effectively increase anaerobic capacity of professional soccer players. This recommendation was also reinforced by the increase of cortisol which appears to be the hormone that is affected most in response to competitive games. We further suggest soccer practitioners and sport scientists to consider using combined methods of monitoring external and internal training load (e.g., time-motion analysis, accelerometers, blood lactate), to simulate the competitive environment of a game. It is essential for soccer practitioners to be aware of which format of SSG to apply and which day of the competitive and precompetitive period during periodization of workloads, so as to maximize players' performance. Future studies are suggested to examine several formats of SSGs (i.e. dimensions, players' number) and the consequences on the biochemical profile of players.

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