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Does aerobic exercise have a beneficial effect on plasma lipid profile in young soccer players?

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Abstract

Introduction. Aerobic training plays an important role in soccer and is designed to improve players' cardiovascular health. Aim of Study. The aim of this study was to assess the impact of a semi-long distance outdoor run on the lipid profile of soccer players. Material and Methods. Plasma activity of lipase (LP) and blood levels of triglycerides (TG), total cholesterol (TC), lipoproteins cholesterol: HDL-C and LDL-C, were determined among sixteen (8 male and 8 female) soccer players, before, immediately after the run, and at the beginning of recovery time (30 minutes after the run). Results. The semi-long distance outdoor run caused a 30% decrease in the TG level in both studied groups (p = 0.0019 and p = 0.0002, pre-exercise vs. post-exercise for males and females, respectively). Post-exercise changes in TC (p = 0.0121 and p = 0.0158, pre-exercise vs. post-exercise for males and females, respectively) were observed. The changes in HDL-C level (p = 0.0001 pre-exercise vs. post-exercise) in males and LDL-C level (p = 0.00003 pre-exercise vs. post-exercise) in female soccer players were also found. Additionally, there were no post-exercise changes in LP activity among the studied female players, however, a significant (p = 0.0119) post-exercise decrease in LP activity among the male players was found. Conclusions. Post-exercise changes in lipid profile and LP activity (at least among males) are markers of soccer players' biochemical adaptation to the training process.

KEYWORDS: aerobic training, athletes, lipase activity, lipid profile.

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What is already known on this topic?
It is well known that aerobic-type exercise improves lipid profiles, cardio-respiratory fitness and body composition in healthy, young individuals. A training programme implemented during the training season causes a disturbance of homeostasis, including lipid profile among athletes. Post-exercise changes in lipid profile and LP activity constitute a biochemical adaptation to the training process and are related to the regularly increased energy turnover, which comes together with increased hydrolysis of triglycerides and elevated lipid oxidation.

Introduction

Numerous literature data confirm that regular exercise is a valuable tool in easing the global burden of chronic disease. Exercise influences glycaemia and triglyceridemia in healthy individuals [1-3]. Interestingly, professional athletes, by definition, meet the conditions recommended for cardiovascular disease prevention [4]. It is suggested that aerobic-type exercise improves lipid profiles, cardiorespiratory fitness and body composition

in young healthy individuals [5]. On the other hand, it was evidenced that moderate-intensity training once a week, lasting for at least 12 weeks, was sufficient to increase aerobic fitness in sedentary young males, but a supramaximal exercise session had no significant effects on lipid metabolism in studied participants [6]. Hurley also suggested that there was a reduction in triglyceride levels but no change in total cholesterol or lipoprotein levels in blood of non-athletes participating in aerobic-type exercise training [6]. Bajpeyi et al. reported no changes in lipids or lipoproteins in a group of inactive controls. Thus, they concluded that resistive training appeared not to alter lipid profiles in individuals at risk of coronary heart disease [7]. In most sedentary individuals, physical exercise is profitable for the blood lipid profile. It must be pointed out that the benefits from a decrease in exercise-related lipid profile are maintained as long as the training is practised [4].

It is known that elevated aerobic energy expenditure is associated with a highly favourable stabilization of most known traditional as well as emerging cardiovascular risk predictors [8, 9]. Physical effort in soccer is both of aerobic and anaerobic type, which is associated with the different activities of a player during the match. The number of accelerations and decelerations during match play impose an additional burden on the muscles [10-12]. This is why soccer players must adapt to generate energy using both anaerobic and aerobic metabolic pathways.

Literature data reveal differences in biochemical parameters resulting from physical exercise as well as relationships of those changes with subjects' fitness level. Moreover, abnormalities in values of biochemical parameters have often no clinical significance in the case of elite athletes [13]. Hence, it is important to establish the influence of different types of exercise, especially in aerobic conditions, on changes of the lipid profile as a source of energy in athletes.

Aim of Study

The aim of this study was to assess the impact of semi-long distance outdoor running in aerobic conditions on the plasma lipid profile in male and female soccer players.

Methods

Study design

In soccer, aerobic training plays an important role in soccer and is designed, among many things, to improve players' cardiovascular health. During soccer matches as well as training sessions it is imperative that a good supply of oxygen is supplied to players' active muscles, and that the muscles have the capability to use the oxygen provided by the circulatory system [14]. Due to the different types of exercise, soccer players must be adapted to generate energy using both anaerobic and aerobic metabolic pathways. It seems unclear whether aerobic training is enough for soccer players to achieve an 'energy expenditure threshold', and whether it can influence the lipid profile in soccer players' blood.

The present study aimed to assess the impact of a semi-long distance outdoor run on the lipid profile in male and female soccer players' blood.

Subjects

The participants (n = 16) were soccer players from the Olimpia Szczecin and the Pogoń Szczecin soccer clubs and were divided into two groups according to sex. The female players were recruited from among healthy premenopausal volunteers, who declared to be in the luteal phase of the menstrual cycle. They had no history of gynaecological problems, endometriosis, and had not used oral contraceptives during the past three months. The participants had no history of metabolic or cardiovascular diseases. They were also non-smokers and refrained from taking any medications or supplements known to affect metabolism.

The study was conducted in accordance with the ethical standards as described by Kruk [15]. The participants (and their parents, where appropriate) were informed of the experimental procedures and possible risks of the experiment before giving their written consent to participate. The local ethics committee approval was received before the commencement of the tests in accordance with the Declaration of Helsinki.

Procedures

The exercise test was performed on the last day of the training season, on a warm, cloudless, summer afternoon. The overall conditions (time of day, sleep, diet, and hydration) reflected participants' typical training conditions as closely as possible. Physiologically, the participants were in the restitution phase of the training cycle. The exercise test consisted of a warm-up routine (10 minutes), the

main run (60 minutes), and stretching and breathing exercises (15 minutes). The aim of the exercise was to develop aerobic efficiency below the anaerobic threshold, calculated individually for each participant. To this end, participants were running to maintain a subliminal heart rate of 158 ± 3 bpm^{-1}. The female players ran outdoors covering a distance of 7.4 ± 0.3 km with a mean speed of 7.5 ± 0.5 $km \cdot h^{-1}$. The male participants ran a semi-long distance of 10.7 ± 1.0 km with a mean speed of 10.6 ± 1.7 $km \cdot h^{-1}$. Heart rate was analysed using a Garmin Forerunner 305 heart rate monitor (Garmin (Europe) Ltd., Romsey, UK). Additionally, the lactate concentration was determined to ensure aerobic metabolism in both studied groups. Blood samples were taken before (pre-exercise), immediately after (post-exercise) a 60-min-long outdoor run at a pace ensuring aerobic metabolism (as ensured by individually calculated and monitored heart rate and confirmed by serum lactate level determination), and at the onset of recovery, 30 min after the run (recovery).

Blood plasma was obtained following standard diagnostic procedures. Blood samples were taken using a 4.9 mL S-Monovette tube with ethylenediaminetetraacetic acid (EDTA) and separating gel. Blood samples were centrifuged 500 × *g* for 15 minutes at room temperature in order to receive blood plasma. The collected plasma samples were frozen at −86°C until further analysis. Blood plasma was used to determine the lipid profile: triglycerides level (TG), total cholesterol level (TC), high-density lipoprotein cholesterol level (HDL-C), low-density lipoprotein cholesterol level (LDL-C), and triacylglycerol lipase (LP; EC 3.1.1.3) activity. The plasma lactate level was determined using diagnostic colorimetric enzymatic method (Liquick Cor-LACTATE) according to the manufacturer's protocol (PZ Cormay S.A., Łomianki, Poland). Absorption of samples was measured at λ = 520 nm at 37°C. Plasma TG and TC levels ($mmol \cdot L^{-1}$) were determined using diagnostic colorimetric enzymatic method according to the manufacturer's protocol (BioMaxima S.A., Lublin, Poland). Absorption of samples was measured at λ = 510 nm at 37°C. HDL-C plasma level ($mmol \cdot L^{-1}$) was determined using human anti-β-lipoprotein antibody and colorimetric enzymatic method according to the manufacturer's protocol (BioMaxima S.A., Lublin, Poland). LDL-C plasma level ($mmol \cdot L^{-1}$) was determined using direct method according to the manufacturer's protocol (PZ Cormay S.A., Łomianki, Poland). ΔA measurements were conducted at λ = 600 nm at 37°C for HDL-C and LDL-C. Plasma LP activity ($U \cdot L^{-1}$) was determined using an appropriate kinetic assay kit according to the manufacturer's protocol (Quimica Clinica Aplicada S.A., Amposta, Spain). The reaction was initiated by the addition of plasma to assay kit reaction mixtures and conducted at 37°C. ΔA measurements were carried out at λ = 578 nm.

All analytical procedures were validated with the use of multiparameteric control serum (BIOLABO S.A.S, Maizy, France) as well as control serum of normal level (BioNormL) and high level of lipids (BioPathL) (BioMaxima S.A., Lublin, Poland). The ranges of reference values of each parameter analysed in the study were based on data provided in the manufacturer's protocol.

Absorption measurements were made using a SEMCO S91E spectrophotometer (EMCO, Warszawa, Poland).

Statistical analysis

All data are presented as mean ± standard deviation. Statistical analyses were performed using STATISTICA (data analysis software system), version 10 software (StatSoft, Inc. (2011)). Statistical analysis of data distribution was performed using a Shapiro-Wilk test. The significance level of differences observed between analysed time points (pre-exercise vs. post-exercise vs. recovery) was assessed using analysis of variance (ANOVA) with repeated measures test followed by contrast analyses, since the results were normally distributed. Statistical power of the tests was calculated using G* Power version 3.1.9.2 software (http://www.gpower.hhu.de). The level of statistical significance was set at $p < 0.05$.

Results

The participants were divided into two groups according to sex. The major differences between male and female soccer players were found in the age (18.4 ± 0.5 and 21.9 ± 2.0 years, for males and females, respectively), body weight (68.6 ± 9.3 and 60.6 ± 5.0 kg for males and females, respectively), and body height (1.78 ± 0.09 and 1.67 ± 0.03 m for males and females, respectively). Both groups showed a similar length of training experience (9.1 ± 1.8 and 8.6 ± 1.1 years, for males and females, respectively).

Table 1. Mean blood level of lactate (mmol·L^{-1}) in male and female soccer players determined before (pre-exercise), immediately after (post-exercise) a 60-min-long outdoor run at a pace ensuring aerobic metabolism (as ensured by individually calculated and monitored heart rate) and at the beginning of recovery – 30 min after the run (recovery)

	Pre-exercise			Post-exercise			Recovery		
Sex	Mean	SD	SEM	Mean	SD	SEM	Mean	SD	SEM
M (n = 8)	2.84	0.35	0.12	2.83	0.35	0.12	2.70	0.28	0.10
W (n = 8)	2.81	0.26	0.09	2.54	0.30	0.11	2.68	0.38	0.14

SD – standard deviation
SEM – standard error of the mean

It was evidenced in the study that 60 minutes of outdoor running did not influence lactate levels in the studied athletes' blood (Table 1). It was found that the exercise test caused about 30% decrease in TG levels regardless of the sex (Figure 1). Interestingly, a significant decrease in TG levels, in comparison to baseline, was also observed at the beginning of recovery time (p = 0.0004 and p = 0.0054 for males and females, respectively), but there were no significant differences between post-exercise and recovery TG level values (Figure 1).

Similar observations were also found in the case of TC level among both males and females (Figure 2).

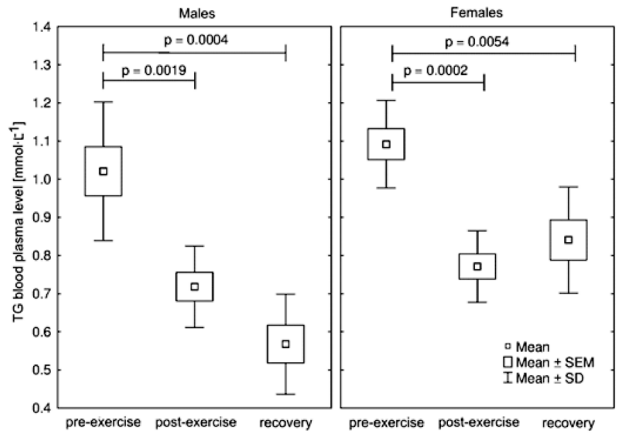

Figure 1. Mean blood level of triglycerides (TG) (mmol·L^{-1}) in male and female soccer players determined before (pre-exercise), immediately after (post-exercise) a 60-min-long outdoor run at a pace ensuring aerobic metabolism (as ensured by individually calculated and monitored heart rate and confirmed by serum lactate level determination) and at the beginning of recovery (recovery) – 30 min after the run. The midpoint represents mean; a box represents standard error of the mean (SEM); the whiskers represent standard deviation (SD). The significance level of differences between analysed time points (pre-exercise vs. post-exercise vs. recovery) was assessed using analysis of variance (ANOVA) with repeated measures test followed by contrast analyses. The statistical power of the test was equal to 0.99 in both males and females, respectively. $p < 0.05$ was considered a significant difference. TG plasma levels were measured among 16 participants: 8 males and 8 females.

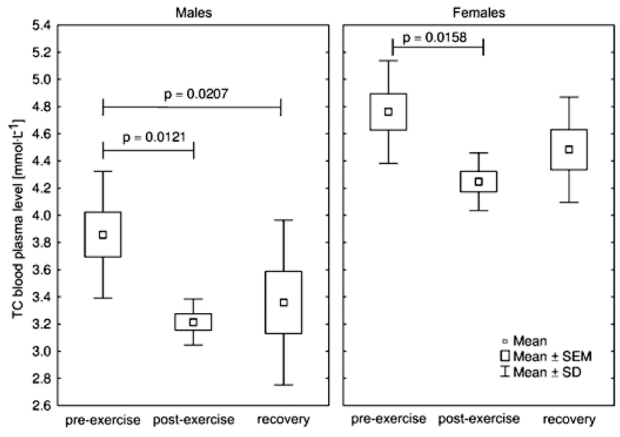

Figure 2. Mean blood level of total cholesterol (TC) (mmol·L^{-1}) in male and female soccer players determined before (pre-exercise), immediately after (post-exercise) a 60-min-long outdoor run at a pace ensuring aerobic metabolism (as ensured by individually calculated and monitored heart rate and confirmed by serum lactate level determination) and at the beginning of recovery (recovery) – 30 min after the run. The midpoint represents mean; a box represents standard error of the mean (SEM); the whiskers represent standard deviation (SD). The significance level of differences between analysed time points (pre-exercise vs. post-exercise vs. recovery) was assessed using analysis of variance (ANOVA) with repeated measures test followed by contrast analyses. The statistical power of the test was equal to 0.82 and 0.70 in males and females, respectively. $p < 0.05$ was considered a significant difference. TC plasma levels were measured in 16 participants: 8 men and 8 women.

However, the differences were lower and reached ca. 10% in both sexes. It is worth noting that a significant decrease in TC levels at the beginning of recovery time in comparison to baseline values were observed only among the male players ($p = 0.0207$).

It was found that the semi-long outdoor run caused a significant change in HDL-C and LDL-C profile in the female group, but there were no post-exercise changes in LDL-C level in the male group (Figure 3, 4). The exercise test caused an increase in HDL-C in women

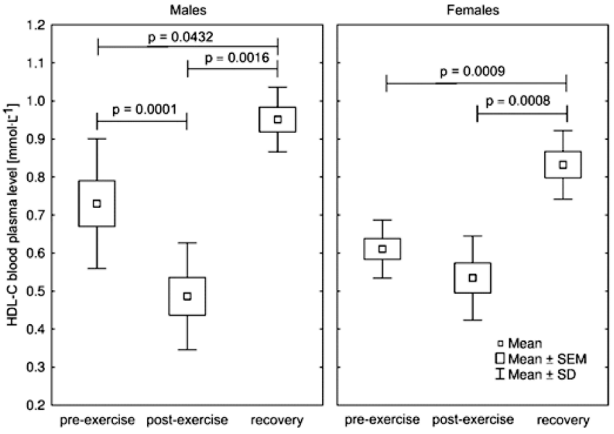

Figure 3. Mean blood level of high-density lipoprotein cholesterol (HDL-C) (mmol·L^{-1}) in male and female soccer players determined before (pre-exercise), immediately after (post-exercise) a 60-min-long outdoor run at a pace ensuring aerobic metabolism (as ensured by individually calculated and monitored heart rate and confirmed by serum lactate level determination) and at the beginning of recovery (recovery) – 30 min after the run. The midpoint represents mean; a box represents standard error of the mean (SEM); the whiskers represent standard deviation (SD). The significance level of differences between analysed time points (pre-exercise vs. post-exercise vs. recovery) was assessed using analysis of variance (ANOVA) with repeated measures test followed by contrast analyses. The statistical power of the test was equal to 0.99 in both males and females, respectively. $p < 0.05$ was considered a significant difference. HDL-C plasma levels were measured in 16 participants: 8 men and 8 women.

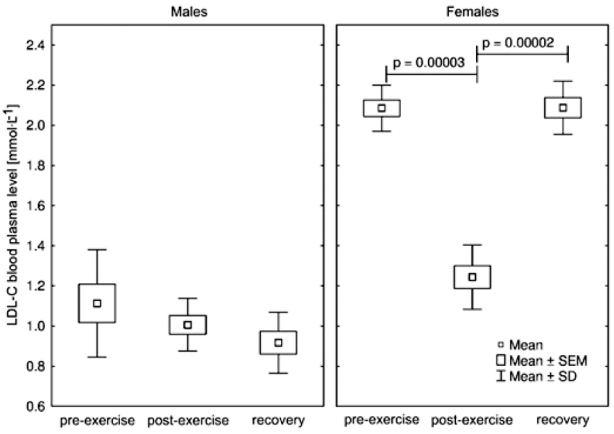

Figure 4. Mean blood level of low-density lipoprotein cholesterol (LDL-C) (mmol·L^{-1}) in male and female soccer players determined before (pre-exercise), immediately after (post-exercise) a 60-min-long outdoor run at a pace ensuring aerobic metabolism (as ensured by individually calculated and monitored heart rate and confirmed by serum lactate level determination) and at the beginning of recovery (recovery) – 30 min after the run. The midpoint represents mean; a box represents standard error of the mean (SEM); the whiskers represent standard deviation (SD). The significance level of differences between analysed time points (pre-exercise vs. post-exercise vs. recovery) was assessed using analysis of variance (ANOVA) with repeated measures test followed by contrast analyses. The statistical power of the test was equal to 0.99 in the female players. $p < 0.05$ was considered a significant difference. LDL-C plasma levels were measured in 16 participants: 8 men and 8 women.

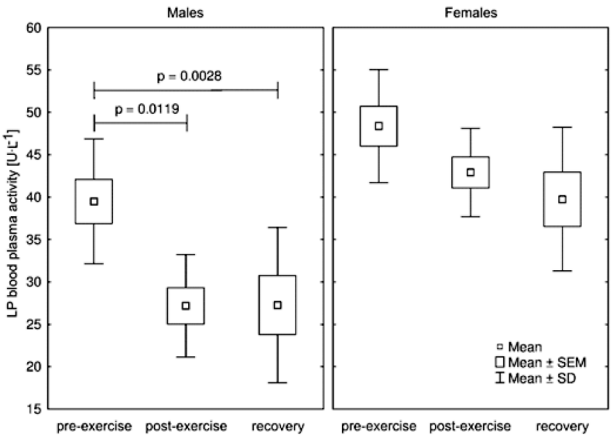

Figure 5. Mean blood plasma lipase (LP) activity (U·L^{-1}) in male and female soccer players determined before (pre-exercise), immediately after (post-exercise) a 60-min-long outdoor run at a pace ensuring aerobic metabolism (as ensured by individually calculated and monitored heart rate and confirmed by serum lactate level determination) and at the beginning of recovery (recovery) – 30 min after the run. The midpoint represents mean; a box represents standard error of the mean (SEM); the whiskers represent standard deviation (SD). The significance level of differences observed between analysed time points (pre-exercise vs. post-exercise vs. recovery) was assessed using analysis of variance (ANOVA) with repeated measures test followed by contrast analyses. The statistical power of the test was equal to 0.91 in the female players. $p < 0.05$ was considered a significant difference. LP plasma activities were measured in 16 participants: 8 men and 8 women.

at the beginning of the recovery. About 40% decrease in LDL-C level post-exercise in the female group was also observed (Figure 3, 4). Interestingly, an increase in HDL-C was found at the beginning of recovery time as compared to its post-exercise level in both groups (Figure 3).

Additionally, the baseline TG, TC and LDL-C found in both studied groups were within the range of reference values provided by the manufacturers of the protocols used for analyses (< 1.7 $mmol \cdot L^{-1}$; < 5.2 $mmol \cdot L^{-1}$; < 2.59 $mmol \cdot L^{-1}$ for TG, TC and LDL-C, respectively), but the baseline values of HDL-C were lower than the lower reference range (0.91 – 1.56 $mmol \cdot L^{-1}$) for both male and female soccer players.

It was noted that a 60-minute outdoor run in aerobic conditions did not influence LP activity in the female group (Figure 5). Moreover, the baseline values found in both studied groups were within the reference range (< 60 $U \cdot L^{-1}$) as provided by the protocol's manufacturer. It was evidenced that after the outdoor run the LP activity in the male group was significantly lower both post-exercise and at the onset of recovery (Figure 5).

Discussion

Physical activity induces changes in athletes' metabolism, which can lead to a differentiation of multiple biochemical parameters in blood. Those parameters' values often exceed reference ranges for the non-training population. It can be associated with the type of training, length of training experience, participation in competitions as well as personal features [4].

Our study indicated that a semi-long distance outdoor run caused a significant decrease in the TG level in both male and female players. These results suggested that this type of exercise induced metabolic changes based on aerobic catabolic pathways as a source of energy. Interestingly, we found that a TG decrease was also observed at the beginning of recovery time in both sexes in comparison to baseline values. Therefore, we suggest that the beginning of homeostasis rebuilding is also associated with the aerobic source of energy at least among soccer players. Our results are in line with data showing that the baseline values of TG are lower than the values for non-athletes [4, 16]. Taking all that into account, it seems that changes in the TG blood level constitute one of biochemical mechanisms of athletes' adaptation to the training process. From this point of view, an adequate training programme could be also a valuable tool to prevent a hypertriglyceridemia in non-athletes.

The data in our study showed that an outdoor run performed by male and female soccer players influenced their TC blood level, which remains in accordance with data by Lippi et al. [8] and Cardoso et al. [17]. Interestingly, we found a significant decrease in TC level after the aerobic exercise, yet at the beginning of recovery time the TC level was comparable to its baseline value. On the other hand, it is well known that the repeated activation of lipolysis results in a greater breakdown of triglyceride-transporting lipoproteins (chylomicrons and very low density lipoprotein cholesterol) and increases the circulating levels of HDL-C [2, 4, 6, 8, 18]. We confirmed that submaximal exercise caused changes in both HDL-C and LDL-C levels in female soccer players, yet among men we found changes only in the HDL-C level. Interestingly, it was observed that the exercise test caused an increase in HDL-C level at the beginning of recovery time in both sexes. Thus, we conclude that these changes are related to biochemical adaptation to the training process of, at least, soccer players. The biochemical adaptations are associated with intensified lipolysis. Those favorable changes in lipid profile variables in response to physical exercise in both athletes and non-athletes were also described by other authors [5, 6, 8, 18-21].

To the best of our knowledge, there has been no information about LP (EC 3.1.1.3) post-exercise changes in athletes' blood, but there are various data proving that exercise training programmes influenced also the activity of another lipid-associated enzyme, namely lipoprotein lipase (LPL; EC 3.1.1.34) catalysing the same type of reaction (hydrolysis of triacylglycerols); however, only in chylomicrons and very low-density lipoproteins. Physical exercise does cause a significant increase in LPL activity [22-24]. Moreover, there is no information about baseline values of LP activity in athletes. It must be also emphasized that biochemical parameters tested during routine training monitoring often differ from reference values for general population [13]. Our study revealed that a semi-long distance outdoor run caused a significant decrease in LP activity in examined male soccer players. Interestingly, at the beginning of recovery, LP activities were still lower than the baseline values in both male and female soccer players participating

in the study. Additionally, the baseline values among studied participants were within the reference range established by the manufacturer of the protocol used for analysis for the general population (< 60 $U \cdot L^{-1}$). Our results indicate that LP could be a useful marker for the assessment of athletes' metabolic response to physical training in aerobic conditions.

An adequate training programme implemented during the training season causes a disturbance of homeostasis in athletes. Physiological and biochemical changes are related to adaptation to physical exercise that increases the aerobic and anaerobic performance of athletes. Our study indicated that post-exercise changes in lipid profile and LP activity reflected the biochemical adaptation of soccer players to the training process. These adaptations are related to the regularly increased energy turnover, which comes together with increased hydrolysis of triglycerides and elevated lipid oxidation. We are aware that our study groups are small and more work needs to be done. Our data are preliminary and we agree that the data from longer studies and larger groups of individuals are more reliable. We plan to cooperate with soccer clubs to elaborate further on our hypotheses. However, our main goal in this study was to evaluate the use of lipid profile for assessment of the metabolic response to aerobic exercise based on the example of semi-long distance outdoor run in soccer players, especially that aerobic training plays a key role in increasing the efficiency of metabolic adaptations and improving the oxygen transport system. This is why we chose an experimental model in which the overall conditions of the time of day, sleep, diet, and hydration were as similar as possible to typical conditions in which the players normally trained. Also, we could not verify the diet and hydration of the participants and we had to rely on their declarations. On the other hand, close cooperation and honesty, especially in regard of any diet supplements, alcohol, or drugs intake etc., between the athlete and the trainer is a key to success. Without it, it is impossible to obtain reliable data and to interpret it correctly.

Conclusions

An adequate training programme during the training season causes a disturbance of homeostasis, including the lipid profile, among athletes. These changes, among others, are related to the adaptation to physical exercise increasing the aerobic and anaerobic performance of athletes. Post-exercise changes in lipid profile and LP activity constitute a biochemical adaptation to the training process and are related to the regularly increased energy turnover, which comes together with increased hydrolysis of triglycerides and elevated lipid oxidation.

The present study showed that post-exercise changes in lipid profile and activity of LP are markers of biochemical adaptation to the training process of soccer players. Moreover, in our opinion, an adequate training programme combined with blood lipid profile assessment could also be a valuable tool for prevention of hyperlipidaemias in non-athletes.

What this study adds?

Considering the importance of aerobic aspects of training of soccer players, we indicated that a semi-long distance outdoor run caused significant post-exercise changes in the TG, TC, HDL-C and LDL-C levels in female soccer players, whereas in male soccer players only changes in TG, TC and HDL-C were found. Our data suggest that the onset of homeostasis restoration is associated with the aerobic source of energy. Additionally, to the best of our knowledge, there is no available data on post-exercise LP (EC 3.1.1.3) changes in athletes' blood. Our study revealed that LP, combined with lipid profile, could be a useful marker for the assessment of athletes' metabolic response to physical exercise in aerobic conditions.

Furthermore, it seems that an adequate training programme could be a valuable tool to prevent hyperlipidaemias in non-athletes as well.

Acknowledgments

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