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Recreational Soccer, Body Composition and Cardiometabolic Health: A Training-Intervention Study in Healthy Adolescents

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Abstract Recreational soccer (RS) is widely used for adolescents as a physical activity method. However, its impact on physical fitness, body composition and metabolic health in adolescents has not been extensively examined yet. The purpose of the present study was to examine the contribution of changes in body fatness and aerobic capacity to modifications in circulating blood lipids profile, following 8-weeks of RS in healthy youth. Fifty-three healthy male adolescents were separated in three groups: one performed RS (3 times x 60 min/week); the other two were served as control groups [soccer-specific training (SST) one and inactive one]. Physical fitness, body composition and blood lipids and glucose responses were evaluated before and after 8-weeks of exercise intervention. Post-intervention body weight and body fat percentage (BF%) were lowered, while physical fitness was improved ($p < 0.05$) in SST group only. High density lipoprotein cholesterol (HDL-C) was higher (n^2 = .378) and total cholesterol (TC)/HDL-C ratio was lower (n^2 = .195) in the SST group relative to RS and inactive groups ($p < 0.05$). In conclusion, although RS may improve aerobic capacity, relative to inactive control group, it does not influence body fatness and cardiometabolic health in adolescents. Consequently, RS may not secure health benefit during the crucial transition period from adolescence to adulthood.

Keywords Adolescents, Physical Fitness, Body Composition, Blood Metabolites, Health

1. Introduction

A low level of physical fitness, life-style related diseases and familial hypercholesterolaemia during childhood were suggested to be positively correlated with an increased risk of cardiovascular disease (CVD), obesity and hypercholesterolemia during adulthood [1-3]. A cross-sectional study for example, suggested that unfit girls and boys (12-19 years of age) were significantly more likely to develop hypercholesterolemia and had a low circulating high density lipoprotein cholesterol (HDL-C), in comparison to moderate and highly fit counterparts [4]. Consequently, the lack of sufficient physical fitness during adolescence may increase the modifiable risk factors during the transition from adolescence to adulthood [5].

Physical activity therefore, might be used as a natural method for potentially lowering circulating blood lipids and increasing the proportion of HDL-C in children [4,6] adolescents [7] and adults [8]. Such exercise modes, which may also motivate substantially children and teenagers to start getting involved in exercise patterns, were found to be the team sports and the recreational soccer (RS) particularly [6,9-16].

In overweight and obese children (11-13 years), 12-weeks of RS (3 times/week x ~60 min per session) and high intensity interval training (HIIT) both were found to improve similarly muscular and cardiorespiratory fitness and health-related markers [15,16]. Hammami et al. [9 also observed that RS (3 times/week) improved physical fitness leading to health benefit in both sedentary individuals and clinical patients in all ages and it is a highly motivated physical activity method for enhancing public health. Finally, Milanović et al. [6] found that RS was effective in improving physical fitness and subsequently health-related components in exercise group compared with the no-exercise control group.

A traditional, however, methodological approach to observe whether a given training intervention may induce health benefits, is to evaluate untrained individuals with or without a pre-intervention extra body weight and/or hypercholesterolemia and compare their results with post-exercise intervention (for review see Kelley et al. [17] and Zouhal et al. [18]). Consequently, the limited pertinent available results exist from healthy, non-over weighted/obese, or hypercholesteraemic youth, would advocate for more studies to be conducted for examining the effect of RS on physical fitness and health indices. In addition, no studies so far have been evaluated the effect of RS on physical fitness, body composition and circulating blood lipid levels and compare these results with two control groups (see methods section).

The aim therefore, of the current study was to examine the contribution of changes in body fatness and physical fitness capacity to modifications in circulating blood lipids levels, following eight weeks of RS in healthy youth. It was hypothesized that RS can contribute to maintaining normal body fatness but would not substantially influence circulating "bad" blood lipids or enhancing physical fitness and HDL-C in an attempt to secure health benefit in adolescents.

2. Materials and Methods

2.1. Participants

Fifty-three (n = 53) young healthy male individuals were initially recruited. Participants' eligibility was assessed by interview and they were fully informed of the tests' protocols and procedures. The study conforms with the Code of Ethics of the World Medical Association (Declaration of Helsinki, 1964) and it was approved by the Institutional Research Ethics Committee (REC-010712). Parental and participants' written informed consent were obtained prior to any assessments. All participants completed medical history questionnaire. None of them was on any medication and/or drug which could influence circulating blood lipids or physical performance. No participant had a history of any disease or evidence of musculoskeletal injury before and during the study period. All participants should be creatine and ergogenic aid supplemented free for at least 8- and 6-weeks respectively, prior to the initiation of the study.

2.2. Study Design

The participants were separated into three groups [soccer-specific training (SST): Control I, n = 20; recreational soccer (RS), n = 21; Control II (inactive one), n = 12]. The participants of the SST group were all members of the same competitive soccer team. Consequently, a randomization was performed only for separating the RS group and the Control (Con) II group. However, for eliminating potential biases, in all physical fitness tests, all participants have received an equal encouragement and motivation and the fitness results are withheld from all participants until the completion of the whole study. The SST and the RS groups received 8 weeks of a soccer-specific pre-seasonal preparation training and a RS training respectively. In purpose, the SST Con I group, received soccer-specific training (double in volume and almost triple in intensity than the volume and intensity of the RS one). The Con II group did not receive any intervention and continued to have their usual lifestyle. Retention of participants was relatively high. Two participants from the SST- and three from the Con-II groups dropped out from blood re-evaluation due to personal reasons. One participant from the SST- and three from the RS-groups dropped out from the fitness re-evaluation due to mild injuries and/or sickness.

For blood and fitness evaluations n = 48 and n = 46 respectively were included into the statistical analysis. Before the start of the training intervention period, and, immediately (within 48-72 h) following the cessation of the training programme, participants visited the laboratory on two occasions for completing all baseline and post-intervention blood, anthropometrics, physiological and physical fitness evaluations [19].

Diet of the participants was controlled by a nutritionist during the whole intervention period providing a caloric-control regimen to all participants. The participants were fully informed about the categories of macronutrients and micronutrients and how appropriate nutrition may affect their growth, performance and health. In addition, the participants were taught various practical ways, such as cups, spoons and digital weight scales, in order to quantify their food intake. Based on the above, they were advised to eat their preferred meals while using the regimen as a guide. All participants were provided with written advice and nutritional examples in order to keep their daily diet as follow: ~50% carbohydrate; ~25% fat; ~25% proteins. Prior also to each fitness evaluation, a specific diet protocol was applied to all participants as follow: ~70% carbohydrate; ~15% fat; ~15% proteins.

Measurements of anthropometrics, physiological (morning session) and most of the physical fitness (afternoon session) evaluations were performed on a single day for all participants. The next day, only the aerobic capacity test was performed. For avoiding diurnal variations all fitness tests were carried out between 5:30-8:30pm in both occasions, after a consumption of a prescribed high carbohydrate meal, as described above, followed by a 3-h fasting-period where water intake was allowed *ad libitum* [20]. All participants rested the day before, and were instructed to avoid any tea, caffeine and alcohol consumption for at least 48-h prior to each physical fitness examination.

2.3. Anthropometrics, Body Composition and Blood Pressure Measurements

Upon arrival at the laboratory, the participants were seated comfortably, and 5 min later, resting heart rate (HR) and blood pressure (BP) were recorded (OMRON M6, Omron Healthcare, Milton Keynes, UK). Body mass and height were determined using a calibrated weight and height scale (Tanita Digital Scale, KD-400, UK). Skinfold thickness (Harpenden caliper, British Indicators Ltd., St. Albans, UK) was measured at seven body sites, and body density and body fat percentage (BF%) were calculated using the equations of Jackson and Pollock [21] and Siri [22] respectively.

2.4. Multistage Fitness Test and Strength Endurance Assessments

Maximum oxygen consumption ($\dot{V}O2_{max}$) was obtained using a multistage fitness test (Bleep test) to the limit of tolerance [23]. The Push-up test was conducted to assess upper body (e.g. arm, shoulder) muscular endurance [24]. Abdominal and hip flexor muscular endurance was assessed using the Abdominal Curl Conditioning Test (Coachwise Ltd, Leeds, U.K.). Participants, were required to perform as many sit-ups as possible, keeping in time to the beeps emitted from the relevant audio CD. The total number of sit-ups completed correctly, until the participant could no longer keep in time with the beeps, was recorded.

All participants from the training groups have previously performed all the above physical-fitness tests several times. However, for muscular endurance tests all participants have performed at least 10 supervised familiarization trails. For the bleep test (not to the point of exhaustion) they performed at least 2 familiarizations. The test-retest reliability [25] for bleep test, BF%, push-ups and sit-ups were $r = 0.97$, $r = 0.96$, $r = 0.93$, $r = 0.95$, respectively.

2.5. Blood Analyses

Participants visited the laboratory, in the morning between 7.00am and 8.30am, after an overnight fast and venous blood samples (10 mL) were collected from an antecubital vein. An amount of ~7 mL of blood was dispensed in plain tubes and allowed to clot for 30 min. The samples then, were centrifuged at 4000rpm for 8 minutes and the serum was decanted. TC, HDL-C and TG were determined using the enzymatic colour test (Beckman Coulter AU 680 analyzer). Low density lipoprotein cholesterol (LDL-C) was calculated using the Friedwald's equations [26]. Atherogenic index was calculated as TC/HDLC. The intra-assay coefficients of variation (CV) for blood assays were all within 5%.

2.6. Exercise Programs

Both the RS and SST were performed on outdoors grass-fields. The eight weeks exercise program of the SST group was based on Jovanovic [27]. The program included 48 soccer-specific training sessions, from 60 min to most likely 1.5-h each and 8 friendly soccer-games. The eight weeks of the RS exercise-intervention included 28 supervised RS games. Each session lasted at around 60 min including ~5 min of standard warm-up and 5 min stretching at the end of each session. The RS games were played with varying rules and with goal keepers. The participants of this group were instructed to play the RS games fairly and with care for each other. The Con II group continued its daily lifestyle performing occasionally some usual physical activities such as walking, joking, cycling or team sports lasted <1-h per week.

2.7. Internal Training Load Determination

The quantification of exercise training was controlled using internal training load (ITL) determination, which was estimated, in arbitrary units (AU), by multiplying the minutes' training duration by session-Ratings of Perceived Exertion (RPE) using the CR10-scale modified by Foster et al [28]. Each participant's session-RPE was recorded about 15-30 min following each training session to ensure that the perceived effort was referred to the whole session rather than the most recent exercise intensity [29]. Prior to the initiation of the training intervention, all participants were fully familiarized with the Borg's Category-Ratio (CR)-10 scale.

2.8. Data Analysis

All data are expressed as the means ± standard deviation (SD) following a test for the normality of distribution (Shapiro-Wilk). Statistical analysis was carried out using a two-way mixed ANOVA for repeated measures (treatment, between groups vs pre-post-treatment, within groups) and a Bonferroni post-hoc test. As effect size (ES) measure of the main effect and the interaction effect, partial η^2 was considered as small if $\eta^2 < 0.06$, and large if $\eta^2 > 0.14$.[30] Statistical significance was declared at $p < 0.05$. The data were analysed using the statistical package SPSS 24 for Windows® (SPSS Inc., USA).

3. Results

3.1. Anthropometrics, Physiological and Fitness Evaluations

The anthropometrics and the physiological/fitness evaluations are presented in Table 1. There were main treatment [F(1,43) = 6.460, p = .004, n^2 = .231] and time [F(1,43) = 7.799, p = .008, n^2 = .154] effects for BF%. Post-training BF% was lower in SST relative to RS [(p = 0.006, 95% Confidence Interval (CI): -1.8093, -.2562)] and Con II (p = 0.001, CI: -2.8758, -.9481) groups. No difference in BF%, between RS and Con II groups was observed (p > 0.05). There were main treatment [F(1,43) = 16.364, p = .000, n^2 = .432] Group x time interaction [F(1,43) = 42.102, p = .0001, n^2 = .662] and time [F(1,43) = 55.766, p = .000, n^2 = .565] effects in $\dot{V}O2_{max}$.

By the end of the training period, $\dot{V}O2_{max}$ was higher in SST group relative to RS (p = 0.012, CI: .6166, 6.1842) and Con II (p = .000, CI: 4.4076, 11.3180) groups. $\dot{V}O2_{max}$ was also higher in RS relative to Con II group (p = 0.007, CI: 1.0377 - 7.8871). There were main treatment [F(1,43) = 9.951, p = .0002, n^2 = .316], Group x time interaction [F(1,43) = 4.106, p = .023, n^2 = .160] and time [F(1,43) = 37.615, p = .0000, n^2 = .467] effects in sit-ups. By the end of the training period, sit-ups were higher in SST group relative to RS (p = 0.000, CI: 1.8736, 10.5825) and Con II (p = .001, CI: 3.0953, 13.9047) groups. There were main treatment [F(1,43) = 6.149, p = .004, n^2 = .222], Group x time interaction [F(1,43) = 4.657, p = .015, n^2 = .178] and time [F(1,43) = 7.248, p = .010, n^2 = .144] effects in push-ups. By the end of the training period, push-ups were higher in SST relative to RS (p = 0.004, CI: 2.7611, 17.7681) group. Height, body weight, BMI, resting BP and resting HR were not different among the groups (p > 0.05). Statistical differences over-time, between Pre- and Post-innervation within the groups, for all variables exhibited main time effect, see Table 1.

Table 1. Anthropometrics, physiological and physical fitness evaluations at baseline and after 8 weeks of training intervention

Anthropometrics	Control I: SST Pre-	Control I: SST Post-	RS Pre-	RS Post-	Control II Pre-	Control II Post-
Age (yrs)	17.0±0.6	17.2±0.6	16.7±0.4	16.9±0.4	16.7±0.4	16.9±0.4
Height (cm)	1.74±.66	1.74±.66	1.73±.1	1.74±.1	1.76±.04	1.77±.04
Weight (kg)	68.5±7.4	66.4±7.2*	66.5±5.5	67.2±5.4	69.7±5.3	69.9±5.1
BMI ($kg \cdot m^{-2}$)	22.5±1.5	21.8±1.5	22.2±1.6	22.2±1.5	22.4±0.9	22.4±0.9
Body fat (%)	9.1±1.0	6.9±0.8*#¤	8.7±1.2	8.5±1.7	9.9±0.8	9.9±0.9
Physiological/Fitness Evaluations						
Systolic BP	125±9.5	123±2.5	124±9	132±8	-	-
Diastolic BP	76.7±6.7	78.1±6.3	76.3±8.2	85.2±7.4	-	-
HR rest (beats/min)	66.7±8.0	62.6±6.6	70.8±9.7	66.4±10	64.7±6.1	63.8±4.4
VO_{2max} ($ml \cdot kg^{-1} \cdot min^{-1}$)	54.3±3.9	58.6±3*#¤	52.1±4.6	52.9±4.5§	48.8±4.6	50.1.±3.8
Sit-ups (rep)	49.1±4.4	54.5±4*#¤	41.7±8	49.5±6.5*	39.4±5.6	42.2±5.8
Push-ups (rep/min)	42.3±10.7	47.6±10*#¤	35.2±9	38.4±10	30.3±6	32.5±5

BMI: Body mass index; BP: Blood pressure; HRrest: Resting heart rate

*Statistical difference over-time, between Pre- and Post-training ($p < 0.05$)

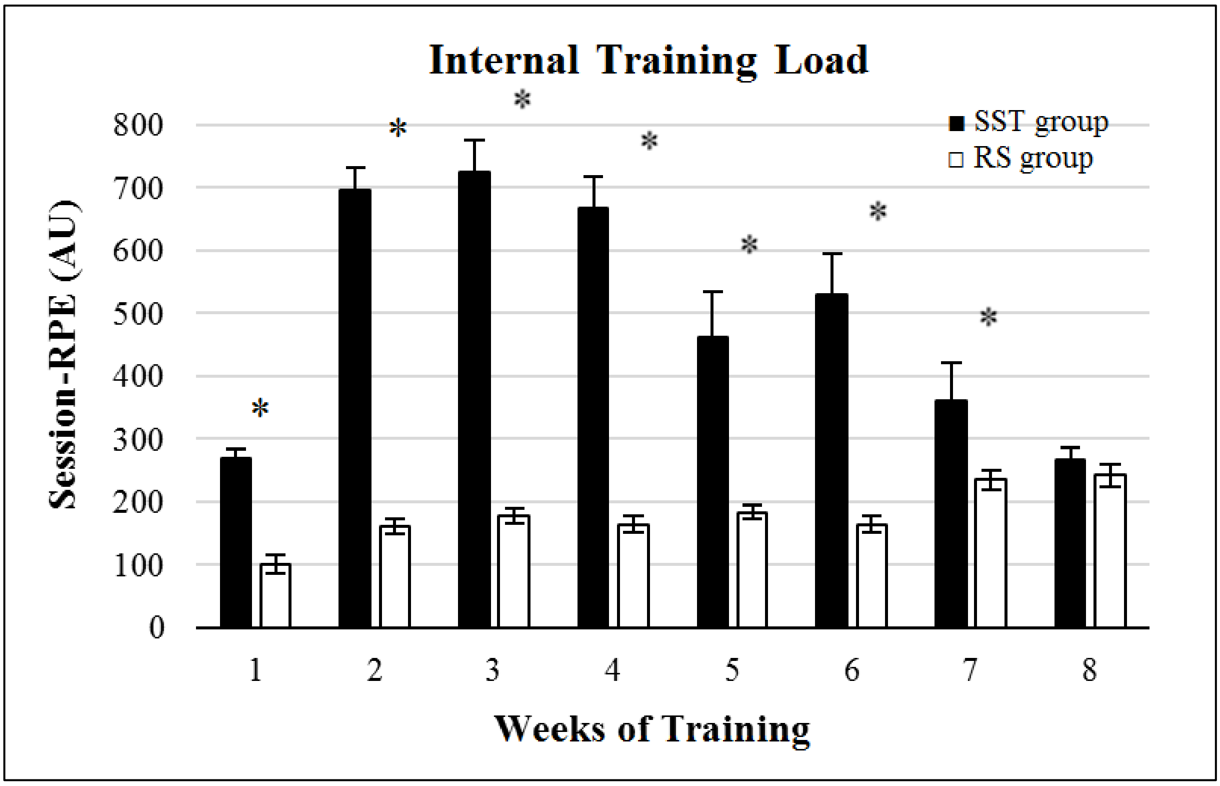
Statistical differences between SST and RS ($p < 0.05$)

¤ Statistical difference between SST and Con II ($p < 0.05$)

§ Statistical differences between RS and Con II ($p < 0.05$)

3.2. Internal Training Load (ITL)

The mean weekly ITL in both groups is shown in Figure 1. Mean weekly session RPE for all training weeks, was significantly higher in SST compared with RS group [F(1,39) = 2080.1, p = 0.0001].



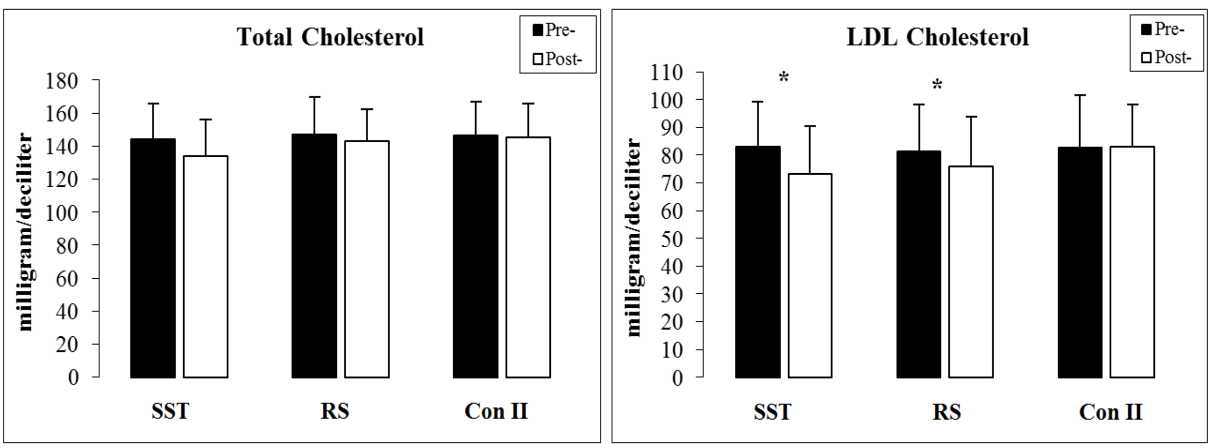
AU, arbitrary unit;

*Statistical difference between SST and RS training groups ($p < 0.05$)

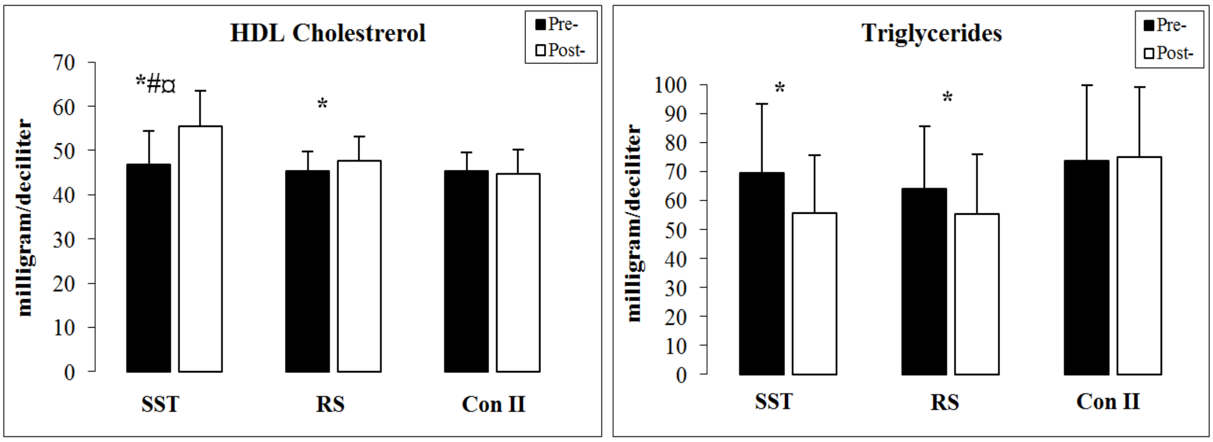
Figure 1. Weekly periodization determined using (CR10-scale) mean weekly RPE-based training load (session-RPE) during the 8 weeks of training intervention in both groups.

3.3. Blood Lipids

The circulating blood lipids are presented in Figure 2.



a b



c d

*Statistical difference over-time, between Pre- and Post-training ($p < 0.05$)

Statistical differences between SST and RS ($p < 0.05$)

¤ Statistical difference between SST and Con II ($p < 0.05$)

§ Statistical differences between RS and Con II ($p < 0.05$)

Figure 2. Plasma Total Cholesterol (a), LDL-Cholesterol (b), HDL-Cholesterol (c) and Triglycerides (d) responses in SST (Con I) and RS groups and in control (Con II).

Plasma HDL-C exhibited significant treatment [$F(1,45) = 4.735$, $p = 0.014$, $n^2 = .378$] and time [$F(1,45) = 21.197$, $p < 0.001$, $n^2 = .320$] main effects, and Groups x time interaction [$F(1,45) = 13.69$, $p = 0.001$, $n^2 = .378$]. Bonferroni also revealed that post-intervention HDL-C was higher in SST relative to RS (p = 0.041, CI: 0.145, 9.260) and Con II (p = 0.035, CI: 0.323, 11.909) groups. Plasma TC:HDL-C ratio exhibited significant treatment [$F(1,45) = 4.532$, $p = 0.016$, $n^2 = .168$] and time [$F(1,45) = 10.760$, $p < 0.002$, $n^2 = .193$] main effects, and Groups x time interaction [$F(1,45) = 5.452$, $p = 0.008$, $n^2 = .195$]. Bonferroni also revealed that post-intervention TC:HDL-C ratio was lower in SST relative to RS (p = 0.050, CI: -.767, .002) and Control (p = 0.037, CI: -1.001, -.023) groups. Only a main time effect was observed in plasma LDL-C [$F(1,45) = 4.368$, $p = 0.042$, $n^2 = .088$]. A main time [$F(1,45) = 10.102$, $p = 0.003$, $n^2 = .183$] and Groups x time interaction [$F(1,45) = 3.386$, $p = 0.043$, $n^2 = .131$] effects were observed in plasma TG. Both post-intervention plasma LDL-C and TG were reduced in both training groups ($p < 0.05$). There were no main time, treatment or Group x time interaction effects on plasma TC ($p > 0.05$).

4. Discussion

The present study examined the effect of RS on the contribution of changes in body fatness and aerobic capacity to modifications in circulating blood lipids in healthy youth. The prototype methodological approach of the current study includes that the two out of the three groups of participants, served as control groups. Instead of having only an inactive control group, a highly active competitive soccer-team group was in purpose also evaluated and included into the statistical analysis. This particular methodological approach increased the external validity of the study, eliminating the potential of either type I or type II statistical errors. In addition, in the current study, instead of using a traditional aerobic exercise or HIIT interventions to examine their effect on physical fitness and metabolic health benefits in adolescents, a RS exercise intervention was used. It was suggested that team sports [11] and RS particularly [9], are more motivating exercise methods for adolescents than the conventional/traditional exercise methods [12].

In the current study, ANOVA analysis revealed that RS was effective in improving aerobic capacity relative to inactive Con II group but no differences observed between RS and Con II groups in muscle strength evaluated parameters as well as in circulating blood lipids and in BF%. In addition, ANOVA analysis, revealed that only the SST exercise intervention (Con I), contributes in significantly improving HDL-C profile by 19.5 ± 13.2%, even in healthy, normolipidaemic, well-trained adolescents. The reduction also in the atherogenic index (TC/HDL-C ratio: -21 ± 11%), observed only in SST and the lack of differences between RS and inactive Con II groups observed in all anthropometrics and blood metabolites as well as in several physical fitness parameters may further justify that 180 minutes per week of RS does not contribute to improving physical fitness or substantially eliciting metabolic health benefit. However, the current study does not intent to propose the soccer-specific training method in the general population adolescents, since it is not a training method that might be easily approachable and applicable for all teenagers. The reasons for including this particular group in the current study design was only for methodological and statistical particularly purposes as well as for quantifying the internal training load (intensity and volume) of the training groups.

For eliminating the risk of developing CVD in adulthood, for anyone aged between 10-19 years, the levels of circulating TC should be less than 200 milligrams per decilitre (mg/dl^{-1}); and for securing health benefits, LDL-C should be below 130 mg/dl^{-1} and HDL-C above 45 mg/dl^{-1} [31]. In both current exercise groups, baseline TC values were below (143 and 146, mg/dl^{-1}, for SST and RS, respectively) the above recommendation for the evaluated age group and it remained unaltered following the 8 weeks of training intervention period. Consequently, since the baseline TC values were initially well below the normal recommendation for the current evaluated aged groups (>200 mg/dl^{-1}), and the participants in both exercise groups were active young, healthy individuals, a significant further reduction in post-intervention TC levels was not potentially expected. A recent study for example showed that 12 weeks of RS [32] had little effect on markers of TC absorption/synthesis in adolescents with type I diabetes.

Similarly, the baseline mean values of the current LDL-C results (83, 81, 82 mg/dl^{-1}, for SST, RS, Con II respectively), were well below the recommended resting LDL-C values (130 mg/dl^{-1}) reported in the literature for this particular age-group [31]. However, although ANOVA revealed no differences among groups in plasma LDL-C and TG, in both exercise groups there was a reduction in plasma LDL-C and TG over-time (pre- vs. post-intervention within the groups), results that are supported by a previous study [16]. These results may suggest a positive effect of both SST and RS on bad lipids metabolic adaptations following 8-weeks of training intervention. However, the results of between groups' effect revealed a significant reduction in circulating LDL-C and TG as well as an increased in HDL-C in SST group relative to both RS and Con II, results that may indicate noteworthy health benefit.

Durstine et al. [33] for example, suggested that 2 to 3 mg/dl^{-1} increases in HDL-C and 8 to 20 mg/dl^{-1} reduction in TG might be evidence for eliciting health benefits. In the SST group of the current study, the mean increase in circulating HDL-C and the reduction in TG and LDL-C were +9 mg/dl^{-1} (19 ± 13%), -14 mg/dl^{-1} (-17 ± 24%) and -10 mg/dl^{-1} (-11 ± 14%), respectively. On the other hand, the increase in HDL-C and the decrease in TG and LDL-C in the RS group were +2 mg/dl^{-1} (5 ± 8%), -8 mg/dl^{-1} (-11 ± 21%) and -5 mg/dl^{-1} (-6 ± 13%), respectively. The current results support Durstine et al. [33] study, indicating the effectiveness of both training groups in reducing circulating TG and LDL-C over-time but the ineffectiveness of RS to significantly elevate HDL-C and reduce TG and LDL-C relative to inactive control group. The current also findings, may response to the conclusion of a previous review by Duffy and Rader [34] who pointed out that in the search for therapies for reducing CVD morbidity and mortality the next step forward is to investigate ways of rising HDL-C levels and/or improving HDL function. In the current study, a natural way to significantly elevate HDL-C levels and reduce the atherogenic index, is the mixed vigorous aerobic and anaerobic (including resistance training sessions) long-term exercise intervention with daily mean ITL of ~480 AU.

For quantifying the intensity of each exercise group, the session RPE for each participant was recorded, between 15-30 minutes following each particular training session. This method, was suggested to successfully monitor exercise training load/intensity in children, adolescents, and adults of both sexes and among various athletic expertise levels [35]. The advantage of this method relative to heart rate recording, is that the whole body exercise/training load is evaluated and not only the heart rate response to exercise stimulus [36]. In addition, by adopting this method during exercise intervention studies, the training load during resistance exercise sessions can be also quantified; something that cannot be detected/evaluated using HR recording *per se* [37]. Consequently, the evaluation of the ITL used in the current study is considered as a valid and reliable method for evaluating the intensity/load/volume of exercise given [38] particularly in the current aged-group evaluated [29,38].

Study Limitations

(1) The randomisation is performed only for separating the RS and Con II groups. However, for eliminating biases, during the physical fitness tests, all participants have received an equal encouragement and the fitness results withheld from all participants until the completion of the whole study.
(2) Hormones regulating lipids metabolism and LDL particle size were not measured.
(3) An estimation of cholesterol absorption, synthesis and metabolism was not performed.
(4) One more RS group, with equal training volume as the current SST, should be included in the design of the study. However, usually adolescents play RS only 2, 3 hours per week [6].
(5) A longer recreational soccer training-intervention period, for at least 6 month, would have provided a better inside into the positive potential changes of biochemical, physiological and physical fitness variables evaluated in the current study.

5. Conclusion

In concussion, RS may provide some physical fitness only benefit to adolescents by improving their aerobic capacity, relative to inactive control group. However, RS did not significantly influence body composition and metabolic health and/or reduce circulating levels of HDL-C and TC:HDL-C ratio (atherogenic index) and BF%.

Consequently, for securing health benefit during the crucial transition period from adolescents to adulthood, a mean weekly ITL of ~180 AU, does not significantly contribute to improving physical fitness and circulating HDL-C and to reducing BF% and atherogenic index in healthy adolescents. Future research may examine the effect of regular RS on health indices in healthy individuals with a genetic predisposition to develop obesity and/or hypercholesterolemia.

Author Statement

Marios Hadjicharalambous: Conceptualization, Study design/methodology, Data collection, Formal data analysis, Writing- Original draft preparation. Writing-Reviewing and Editing, Project administration. Andreas Apostolides: Study design/methodology, Data collection, Formal data analysis, Writing-Reviewing and Editing. Nikolaos Zaras: Study design/methodology, Data collection, Formal data analysis, Writing-Reviewing and Editing. Fotini Tsofliou: Study design/methodology, Data collection, Writing-Reviewing and Editing. All authors read and approved the final manuscript.

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