

# Impact of sports participation on components of metabolic syndrome in adolescents: ABCD Growth Study

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## Research Article

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# Abstract

**Objective** The objective of this study was to analyze the impact of sports participation (12 months of practice) on components of the metabolic syndrome of both sexes.

**Methods** Observational longitudinal study, part of the study entitled "Analysis of Behaviors of Children During Growth" (ABCD Growth Study), Presidente Prudente, SP. The sample consisted of 171 adolescents [112 boys and 59 girls], the groups were divided between non-sport and sport, according to the inclusion criteria: age 11 to 17 years; absence of known diseases previously diagnosed; no regular use of medications related to blood pressure or lipid metabolism; involvement in sports in the last 12 months (sports group) for at least one year without any regular involvement in sports training routines or physical exercises (non-sports group), signed written consent form parents and adolescents. The high-density cholesterol lipoproteins (HDL-c), triglycerides (TG), and glucose were analyzed by the dry chemical colorimetric method and processed biochemically. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were assessed using an automatic device. Body fat (BF) was estimated using a densitometry scanner. Ethnicity, sex, maturity, and body weight were treated as covariates.

**Results** The adolescents involved in the sport were younger [p-value = 0.001] and with lower PVC [p-value = 0.001] than the non-sport group. The differences () after 12 months were of greater magnitude for the sports group when compared to non-sports group [p-value = 0.013], glucose (moderate magnitude in favor of the sports group; p-value = 0.001), HDL-c (small magnitude in favor of the sports group; p-value = 0.0015) and MetS (moderate magnitude in favor of the sports group; p-value = 0.001). Sport with high cardiorespiratory demand has more pronounced benefits than other groups. Sport seems to have a positive relationship in the variables sports participation, weekly volume, and load intensity.

**Conclusion** Sports practice in adolescents had a protective effect on the metabolic components of the metabolic syndrome.

## Introduction

Metabolic Syndrome (MetS) is generally defined by the cluster of cardiovascular risk factors, with three or more markers such as obesity, high blood pressure (HBP), dyslipidemia [increase in triglycerides (TG) and decrease in high-density lipoprotein (HDL)] [1–4]. It is estimated that a total of 34.2% of North Americans have MetS, with 20.2% in young adult men and 16.7% in women [5]. The prevalence of MetS in children and adolescents is about 2% depending on the adopted criteria, also, the prevalence of MetS in the pediatric population has been increasing in parallel with the obesity epidemic [6].

According to the World Health Organization (WHO), obesity is defined as the accumulation of abnormal or excessive fat that poses a health risk [7]. Obesity is present in about 34.8% of men and 36.5% of North American women aged 20 to 39 years [8]. In adolescents, obesity affects about 20.6% (obesity – BMI at or above the sex-specific 95<sup>th</sup> percentile) and 9.1% (extreme obesity – BMI at or above 120% of the sex-specific 95<sup>th</sup> percentile) [9]. The prevalence of blood pressure in children and adolescents (8 to 17 years) affects about 1.6%, dyslipidemia affects about 20.2%, while the prevalence of type II diabetes (T2DM) affects about 0.46% [10, 11].

MetS are directly related to increased sedentary behavior and low levels of physical activity [12]. Physical activity is considered a modifiable factor in lifestyle capable of promoting the prevention and treatment of

cardiovascular and metabolic diseases [13]. According to WHO and The US Preventive Services Task Force (USPSTF), they found evidences which supported that moderate-to-vigorous physical activity (MVPA) accumulated at least 60 minutes is effective to promote improvements - in a short-term (up to 12 months) – on weight status [14, 15]. A 2015 review found positive adaptations to childhood obesity, mainly acting to restore cellular and cardiovascular homeostasis, to improve body composition, and to activate metabolism by any type of physical exercise, [16] following the guidelines outlined by the 2011 National Heart, Lung, and Blood Institute (NHLBI) Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents and more recent studies involving metabolic syndrome in the pediatric population [14, 17, 18].

Physical activity and MetS have opposite effects, physical activity can promote adaptations in the cardiovascular and metabolic components in adolescents [19, 20]. Sports practice is the main manifestation of being from the subdomain of physical activity, becoming the main responsible for the adolescents to reach the levels of MVPA [21, 22]. This sports practice is often carried out at school [23] or by municipal projects. Each sport has different cardiorespiratory demands: High (>6 METs) and Low (<6 METs), being responsible for determining energy expenditure during the activity [24]. Therefore, our hypothesis of sports practice would be able to promote adaptations in lipid metabolism and the cardiovascular system of adolescents, regardless of cardiorespiratory demand. Thereby, this study aimed to analyze the impact of 1-year sports participation on components of metabolic syndrome in adolescents of both sexes.

## Methods

### Sampling

This study is part of longitudinal research entitled Analysis of Behaviors of Children During Growth (ABCD – Growth Study). This is an on-going study designed to identify the impact of sports participation on different health aspects among adolescents, including metabolic syndrome components. The study is being carried out in the city of Presidente Prudente (200,000 inhabitants and human development index of 0.806, the western state of Sao Paulo, Brazil). Researchers and staff members of the Laboratory of Investigation in Exercise (LIVE) (Sao Paulo State University - UNESP) were responsible for the 2017 baseline and follow-up data collection. The ethics committee of the UNESP campus of Presidente Prudente approved the study (process number 1.677.938/2016). All parents, coaches, and adolescents signed a written consent form.

The sampling process has been described elsewhere [25–27]. Briefly, after authorization of local authorities, school units and sports clubs were contacted to explain the research aims and methods of the ABCD – Growth Study. In the eleven facilities (spread out in the metropolitan area of the city) that were accepted to host the research, adolescents and their parents/legal guardians were contacted, and written consent forms were delivered. The only adolescent who fulfills all inclusion criteria were measured/interviewed: (i) aged between 11 and 18 years; (ii) absence of any known diseases previously diagnosed; (iii) no regular medicine use related to blood pressure or lipid metabolism; (iv) if athletes, at least one year of training experience; if control group (schoolchildren), at least one year without any regular engagement in organized sports or physical exercise routines; (v) written parental consent and adolescents' assent, both signed.

At baseline, 285 adolescents agreed to participate and take part in the baseline data collection. Twenty-six adolescents had any missing data at baseline and were excluded from this manuscript (n= 259). Moreover, after

12 months of follow-up, there 75 dropouts due to fear about blood collection, moved to another city, lack of time to participate in data collection, or gave up participating (n= 184). Additionally, 13 adolescents were excluded due to any missing in the components of MetS on follow-up data collection. This sample size of 171 participants allowed the statistical power (80%) to detect significant ( $Z= 1.96$ ) coefficients of correlation (standardized score  $[r] \geq 0.213$  in our statistical analysis).

### **Metabolic syndrome components**

Blood samples were collected in a private laboratory following at least twelve hours of fasting. High-density lipoprotein-cholesterol (HDL-c [mg/dL]), triacylglycerol (TG [mg/dL]), and glucose (mg/dL) were analyzed by the colorimetric method of dry chemistry and processed in a biochemical Autoanalyzer (Vitros, model 250) obtained from the Ortho Clinical Diagnostics company, Rochester, New York, USA. Systolic (SBP) and diastolic blood pressure (DBP) were assessed using an automatic device (Omron Healthcare, Inc., Intellisense, model HEM 742 INT, Bannockburn, Illinois, USA), validated for adolescents [28]. Mean blood pressure (MBP) was calculated using SBP and DBP  $[MBP = 1/3 (SBP - DBP) + DBP]$  [29]. Measurements were performed after 10 minutes at rest and three measurements were obtained with an interval of one minute between them and the mean of the three measurements was considered [30]. Body fatness (BF in percentage values [%]) was estimated using a densitometry scanner (General Electrics; model Lunar – DPX-NT, General Electric Healthcare, Little Chalfont, Buckinghamshire, United Kingdom) equipped with the software GE Medical System Lunar (version 4.7).

To obtain a MetS Z score considering all components, absolute changes ( $[\Delta]$  subtracting baseline value from follow-up value) were converted to standardized z scores ( $[\text{individual value } \Delta - \text{group average } \Delta] / \text{group standard deviation}$ ). A standardized Z score was created summing TG, HDL-c, glucose, MBP, and BF (MetS Z score). To obtain the same meaning of other variables, HDL-c Z score was multiplied by -1 (high values of HDL-c are beneficial to health).

### **Sport participation**

Adolescents were engaged in nine sports (judo [n= 4], karate [n= 14], kung fu [n= 13], gymnastics [n= 10], baseball [n= 10], basketball [n= 16], swimming [n= 24], tennis [n=15] and track & field [n= 8]), while non-sport group was composed of schoolchildren (n= 57). In general, sports with typical physical training involving aerobic fitness (e.g. running activities), usually associated with greater improvements in terms of CRF and intensity above six metabolic equivalents (METs) [24, 31] were classified as high CRF sports (track & field, basketball, swimming and tennis [High CRF Sport; n= 64]). Sports involving less aerobic activities and in which their modality is classified as below six METs [24], those adolescents were classified as low CRF sports (judo, karate, kung fu, gymnastics and baseball [Sport Low-CRF; n= 50]).

Coaches keep contact with researchers during the entire follow-up period and only adolescents who frequently participated in the training sections were reassessed in the follow-up moment. At baseline, it was reported the previous time of engagement in the current sport (in months), the number of days/week training, time spent in the exercise sections (in minutes). Therefore, it also calculated the overall time per week of training (minutes/week).

Additionally, two non-consecutive training sections in the same week were entirely monitored by the researchers. Heart rate (HR) was monitored during the training sections using a Polar V800 HR monitor (a plastic strap was

placed on the trunk to measure HR via telemetry [Polar Electro®, Finland]) and the average values of the two sections were adopted [32]. The average percentage of maximum HR reached during the two sections has been multiplied by the number of training per week of each athlete in order to create a proxy of training load.

## Covariates

Ethnicity (caucasian or others [black, Asian, Native American and others]), chronological age (difference between birthday and baseline measurements), and sex (boy/girl) were self-reported during a face-to-face interview. Bodyweight (electronic scale [Filizzola PL 150, model Filizzola Ltda, Brazil]) and height (wall-mounted stadiometer [Sanny, model American Medical of the Brazil Ltda, Brazil]) were measured according to standardized procedures [33], while the biological maturation was estimated through the peak height velocity (PHV) proposed by MIRWALD *et al.*, (2002) (time in years before [negative score] and after [positive score] the moment of maximum gain of height).

## Statistical analysis

Descriptive data were presented by means and 95% confidence intervals (95%CI). Absolute change ( $\Delta$ ) was calculated using the data of 1-year of follow-up. Analysis of covariance (ANCOVA) was used to compare the components of MetS according to the engagement in sports adjusted by covariates (sex, ethnicity, PHV [baseline], and body fatness [baseline]). Levene's test assessed the assumption of homogeneity of variances in the models, while Bonferroni's post hoc test was used when necessary. Effect size was expressed as eta-squared (ES-r) values and classified as follow: (i) from 0.010 to 0.059 [small]; (ii) 0.060 to 0.139 [moderate]; (iii)  $\geq 0.140$  [elevated] [35]. The relationship between parameters of sports participation and changes on MetS components was assessed using partial correlation, adjusting by sex, ethnicity, PHV (baseline), and body fatness (baseline). Statistical significance was set at 5% ( $p < 0.05$ ). Analyzes were performed using the software BioEstat (version 5.0).

## Results

The adolescents in the sports group were younger ( $p$ -value = 0.001) and with lower PVC ( $p$ -value = 0.001) than the adolescents in the non-sports group. In the parameters of body fat, no significant difference was found between the groups. In the MetS components at baseline, the group of young sportspeople had higher values for glucose ( $p$ -value = 0.001) compared to the non-sports group, while the group of young sportspeople had lower values for depression ( $p$ -value = 0.010) compared to the non-sports group (**Table 1**).

**Table 1.** Characteristics of participants at baseline according to sports participation (n= 171).

	Non-sport (n= 57) Mean (SD)	Sport (n= 114) Mean (SD)	p-value
Sex (Girls / Boys)	19 / 38	40 / 74	---
Ethnicity (White / Others)	32 / 45	51 / 63	---
Chronological age (years)	15.6 (2.1)	13.4 (2.2)	<b>0.001</b>
Body mass (kg)	61.9 (14.1)	58.4 (18.3)	0.147
Height (cm)	166.5 (11.2)	164.4 (14.5)	0.229
PHV (years)	1.8 (1.5)	0.4 (1.9)	<b>0.001</b>
Sports participation parameters*			
Previous time (months)	---	43.5 (46)	---
Volume (min/day)	---	127.5 (90)	---
Frequency (days/wk)	---	4 (4)	---
Weekly volume (min/wk)	---	540 (660)	---
Intensity (% maximum HR)	---	72.3 (9.7)	---
MetS Components*			
TG (mg/dL)	66 (31)	73.5 (34)	0.063
HDL-c (mg/dL)	54 (19)	52 (14)	0.433
Glucose (mg/dL)	78.8 (43.4)	87.3 (8.9)	<b>0.001</b>
MBP (mmHg)	79.7 (8.6)	76.8 (10.5)	<b>0.010</b>
Body fatness (%)	23.4 (19)	21.5 (15)	0.701
MetS Components (%)			
TG ( $\geq 150$ mg/dL)	2 (3.5%)	5 (4.4%)	1.000**
HDL-c ( $< 40$ mg/dL)	4 (7.1%)	13 (11.4%)	0.527
Glucose ( $\geq 100$ mg/dL)	1 (1.8%)	2 (2.6%)	1.000**
MBP ( $\geq 130$ or $\geq 85$ mmHg)	4 (7.1%)	7 (6.1%)	1.000**
BF ( $\geq 30\%$ girls / $\geq 25\%$ boys)	21 (36.8%)	34 (29.8%)	0.451
MetS (yes [ $\geq 3$ components])	1 (1.8)	1 (0.9)	1.000**

SD= standard deviation; PHV= peak height velocity; TG= triglycerides; HDL-c= High Density Cholesterol; MBP= mean blood pressure; BF= body fatness; MetS= metabolic syndrome; \*= variable expressed as median and interquartile range due to non-parametric distribution and, when compared, Mann-Whitney's test has been used; \*\*= Fisher's exact test. Statistically significant values ( $p < 0.05$ ) are given in bold.

Table 2 compares the changes that occurred after 12 months of follow-up between the two formed groups. In the unadjusted analysis, there were differences for the variables TG (p-value = 0.003), HDL (p-value = 0.025), blood glucose (p-value = 0.001) and Z MetS score (p-value = 0.001).

In adjusted analyzes, changes over the follow-up differed between the sports and non-sports groups for TG (-6.24 mg / dL [-12.33 to -0.14] versus 7.78 mg / dL [-0.98 to 16.56]; p-value = 0.013), fasting glucose (-3.04 mg / dL [-5.10 to -0.97] versus 3.62 mg / dL [0.65 to 6.60]; p-value = 0.001), HDL-c (0.17 mg / dL [-1.33 to 1.68] versus -3.22 mg / dL [-5.39 to -1.05]; p-value = 0.015) and Z MetS score (-0.47 [-0.90 to -0.03] versus 1.12 [0.49 to 1.74]; p-value = 0.001) (**Table 2**).

**Table 2.** Absolute change ( $\Delta$ ) in components of metabolic syndrome after 12 months of participation in sports participation among adolescents (n= 171).

	TG (mg/dL)	HDL-c (mg/dL)	Glucose (mg/dL)	MBP (mmHg)	Body fatness (%)	MetS Z score
	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)
<b>Student <i>t</i> test</b>						
Non-Sport (n= 57)	8.73 (1.75 to 15.71)	-2.87 (-4.97 to -0.78)	3.34 (1.19 to 5.49)	2.30 (0.63 to 3.96)	0.76 (-0.64 to 2.16)	1.13 (0.55 to 1.70)
Sport (n= 114)	-6.82 (-13.22 to -0.43)	0.02 (-1.44 to 1.49)	-2.90 (-5.11 to -0.68)	1.84 (0.64 to 3.03)	-0.04 (-0.97 to 0.89)	-0.47 (-0.90 to -0.05)
<i>p</i> -value	0.003	0.025	0.001	0.656	0.337	0.001
<b>ANCOVA*</b>						
Non-Sport (n= 57)	7.78 (-0.98 to 16.56)	-3.22 (-5.39 to -1.05)	3.62 (0.65 to 6.60)	---	---	1.12 (0.49 to 1.74)
Sport (n= 114)	-6.24 (-12.33 to -0.14)	0.17 (-1.33 to 1.68)	-3.04 (-5.10 to -0.97)	---	---	-0.47 (-0.90 to -0.03)
<i>p</i> -value	0.013	0.015	0.001	---	---	0.001
Eta-squared (%)	3.7%	3.7%	7.1%	---	---	8.9%
Magnitude	Small	Small	Moderate	---	---	Moderate

\*= adjusted by sex, maturation, ethnicity, and body fatness (baseline); 95%CI= 95% confidence interval; TG= triglycerides; MBP= mean blood pressure; MetS= metabolic syndrome; ANCOVA= analysis of covariance.

Changes in HDL-c concentrations were positively related to the previous time of sports participation, weekly volume, and training load (low magnitude, ranging from 0.158 to 0.163). Fasting blood glucose (low magnitude, ranging from -0.383 to -0.157) and the Z MetS score (low magnitude, ranging from -0.298 to -0.186) were inversely related to all variables analyzed (**Table 3**).

**Table 3.** Dose-response relationship between changes in components of metabolic syndrome and sports participation parameters in adolescents (n= 171).

	TG (mg/dL)	HDL-c (mg/dL)	Glucose (mg/dL)	MBP (mmHg)	Body fatness (%)	MetS Z score
Sports participation parameters	Correlation* ( <i>r</i> ) <i>p</i> -value					
Previous time (months)	-0.113 0.148	<b>0.163</b> <b>0.036</b>	<b>-0.383</b> <b>0.001</b>	0.026 0.743	-0.086 0.268	<b>-0.298</b> <b>0.001</b>
Volume (min/day)	-0.060 0.442	0.145 0.062	<b>-0.313</b> <b>0.001</b>	-0.057 0.467	-0.056 0.476	<b>-0.260</b> <b>0.001</b>
Frequency (days/wk)	-0.107 0.168	0.150 0.053	<b>-0.157</b> <b>0.043</b>	0.063 0.417	-0.106 0.175	<b>-0.186</b> <b>0.016</b>
Weekly volume (min/wk)	-0.093 0.235	<b>0.158</b> <b>0.042</b>	<b>-0.210</b> <b>0.007</b>	-0.008 0.918	-0.106 0.173	<b>-0.234</b> <b>0.002</b>
Training load§	-0.136 0.080	<b>0.159</b> <b>0.041</b>	<b>-0.200</b> <b>0.010</b>	0.041 0.599	-0.104 0.183	<b>-0.228</b> <b>0.003</b>

\*= Partial correlation adjusted by sex, maturation, ethnicity and body fatness (baseline); §= denotes the intensity (average percentage of the maximum heart rate during the training section) multiplied by the frequency in days; TG= triglycerides; HDL-c= high density lipoprotein-cholesterol; MBP= mean blood pressure; MetS= metabolic syndrome. *p*-value<0.05.

When sports cardiorespiratory demand (low and high) was considered, the mean values of the Z MetS score were negative, and the non-sports group showed positive values (Figure 1).

## Discussion

Our main findings highlight that adolescents engaged in sports practice showed a decrease in risk factors for metabolic syndrome (especially metabolic ones), regardless of body adiposity.

In our sample, at the baseline of the study, most of the adolescents analyzed did not present changes in the metabolic and cardiovascular components considered. Perhaps therefore blood pressure values have not changed significantly. Although reports point to a negative relationship between sports and blood pressure [36, 37] and greater parasympathetic activity among adolescents engaged in sports activities [38, 39], it must be considered that the hypotensive effect of physical exercise on non-obese adolescents is still an unclear aspect in the pediatric literature [40, 41]. Another confounding component in this theme is the fact that blood pressure naturally changes throughout the human growth phase [42]. In this sense, although sports practice in adolescence seems capable of preventing high blood pressure in adulthood [43], further studies are needed to clarify how this relationship behaves during human growth stages.

Unlike the findings for blood pressure, the concentrations of TG, HDL-c, and glucose seemed more susceptible to changes throughout the follow-up (reductions in TG and glucose and increases in HDL-c). On the other hand, although the literature points out that different types of exercise can affect the lipid and glycemic profile in

adults [44–46], these findings are less clear among pediatric groups. Furthermore, the literature has pointed out that the regular practice of physical exercises can affect the components of the lipid profile of obese adolescents, whereas this effect does not seem to be so clear among young people with normal values of body fat [47]. Our findings become more interesting, because (i) it involves sports practice (the main manifestation of physical exercise in adolescence, but little explored in the literature) and (ii) our sample was composed of predominantly non-obese adolescents and with few changes in the components of cardiovascular and metabolic factors considered. Perhaps, for this reason, our findings were, for the most part, of low magnitude.

Another aspect that draws attention is the fact that these changes were observed even in a scenario in which body adiposity remained stable. A hypothesis formulated to support the relationship between physical exercise and lipid profile would be the fact that physical exercise induces changes in the components of the lipid profile through increases in Apolipoprotein A1 (APOA1) [48, 49], which are not exclusively dependent on changes in adiposity [50]. Also, aspects that indicate a longer previous engagement time and the weekly volume of sports practice seem more relevant than the daily time of sports practice.

The lowest values observed in the sports group for the Z MetS score reflect the aggregate effect on metabolic components, but not cardiovascular and adiposity. Although recreational activities can generate benefits for obese and less active adolescents [51, 52], among these young athletes the greater cardiorespiratory demand of some sports activities (intensity indicator) promoted improvements in metabolic aspects [53]. These findings corroborate with some reports in the literature, which highlight the importance of adequately controlling the training load [54].

Our study has some limitations, which need to be recognized. Thus, the lack of control of food consumption (a factor that directly affects biochemical tests) is a relevant limitation in this research. Furthermore, the absence of a more in-depth follow-up on the different competitive calendars of these teenagers also needs to be highlighted.

We conclude that adolescents who practice sports, regardless of body adiposity, have a protective factor in the components of metabolic syndrome.

## **Declarations**

### **Ethics approval and consent to participate**

The study was approved by the Ethics Research Committee of the Sao Paulo State University (process number: 1.677.938/2016 and Process number 02891112.6.0000.5402), Campus of Presidente Prudente. Informed consent was obtained in writing from all individual participants included in the study and their parents or legal guardians.

### **Consent for publication**

Not applicable.

### **Methods**

The methods of study were carried out in accordance with relevant guidelines and regulations including the Declaration of Helsinki for human studies by the World Medical Association.

### **Availability of data and materials**

The datasets generated and/or analyzed during the current study are not publicly available due it contains private information from medical records but are available from the corresponding author on reasonable request.

### **Competing interests**

The authors declare that they have no competing interests.

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### **Author's contributions**

VAM participated in the conception, analysis, interpretation of data, and writing of the article; WT was involved in data collection, revision, and relevant contributions of the text; EDLM was involved in data collection, revision, and relevant contributions of the text; LGMC was involved in data collection, review and relevant contributions to the text; AEVHM was involved in the revision and relevant contributions of the text; JBU was involved in data collection, revision and relevant contributions of the text, AAAJ was involved in the interpretation of data, revision and relevant contributions of the text; DGDC was involved in the interpretation of the data, revision and relevant contributions of the text; RAF was involved in the interpretation of the data, statistical treatment, revision and relevant contributions of the text. All authors read and approved the manuscript.

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# Figures

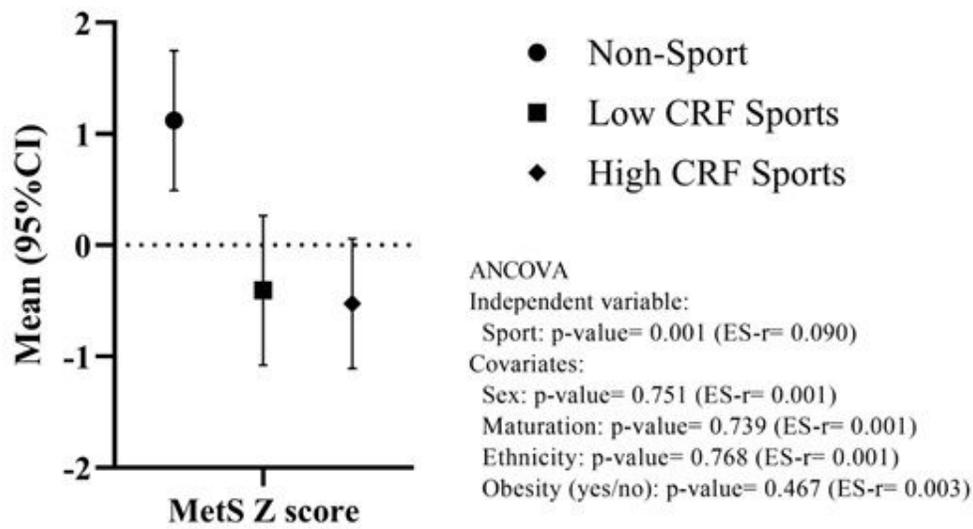


Figure 1

Z MetS score of the groups to the cardiorespiratory demands of sports practice among adolescents.