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ORIGINAL ARTICLE

Sport participation in pediatric age affects modifications in diabetes markers in adulthood

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Abstract The purpose of this study was to analyze the effect of early sport participation on diabetes markers among adults. This longitudinal study analyzed 107 participants during 12 months of follow-up. Diabetes markers were measured by fasting insulin, fasting glucose, insulin resistance, and glycated hemoglobin. Sports participation during childhood and adolescence was self-reported. Current physical activity was measured by pedometer. Adults with no engagement in sports during early life showed positive relationship between current physical inactivity and higher modification in glucose ($\beta = 1.045$ [95%CI 0.267; 1.823]), insulin ($\beta = 0.763$ [95%CI 0.121; 1.405]), and insulin resistance ($\beta = 0.295$ [95%CI 0.062; 0.529]). Adults engaged in sports during early life had lower values of glucose (p value = 0.029; Eta-squared = 0.049). Glucose levels decreased through the follow-up among adults with early sports participation (p value = 0.005; Eta-squared = 0.074). There was association between lack of early engagement in sports and higher occurrence of altered values during the follow-up for insulin resistance (OR = 8.37 [2.10; 33.3]) and insulin (OR = 7.61 [2.27; 25.4]). Engagement in sport activities during early life affects glycemic variables in adulthood, as well as longitudinal relationship between physical activity in adulthood, and glycemic control also seems affected by early sport participation.

Keywords Physical activity and health · Adolescence · Childhood · Insulin resistance · Glycemic control

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Introduction

Type 2 diabetes mellitus (T2DM) constitutes a chronic disease highly prevalent in adults [1], which is associated with elevated health care costs and early mortality [2–4]. Although T2DM constitutes a public health problem mainly observed among adults, alterations observed at adulthood are initiated during early life [5–7]. In fact, the events during early life seem relevant in the programing of organs of the human body and their functions at adulthood and epigenetic pathways have been used to support these theories [8, 9].

Physical inactivity is a relevant risk factor related to the development of T2DM and its complications in adulthood [10, 11]. Interestingly, physical activity during childhood and adolescence constitutes a stressful agent with potential to affect DNA global methylation in adulthood [12], but its protective effects on prevention of diseases are not completely clear [7]. Previous studies reported that early sport participation was related to lower arterial intima-media thickness, better lipid profile, and lower prevalence of arterial hypertension and T2DM in adulthood [11, 13–17].

On the other hand, the impact of exercise routinely performed during early life on diabetes markers in adulthood remains unclear. In fact, the few studies that analyzed T2DM as outcome had cross-sectional design and assessed current physical activity with questionnaire. Therefore, the purpose of this study was to analyze the effect of early sport participation on diabetes markers among adults, as well as to identify if early sport participation affects the relationship between current physical activity and diabetes markers in adulthood.

Methods

Study design, participants and follow-up

This was a prospective longitudinal study analyzing physical activity and diabetes markers at baseline and after 12 months of follow-up. The study was carried out in a Brazilian city (Presidente Prudente, located at western region of Sao Paulo State; ~200,000 inhabitants) from 2013 to 2014. All procedures performed in this longitudinal study were approved by the ethical research group of the Sao Paulo State University (UNESP), Presidente Prudente, Sao Paulo State, Brazil.

The study was presented to four fitness clubs located at different geographical regions of the metropolitan area of the city, as well as all department and centers of research of the university. The inclusion criteria were as follows: (i) aged between 30 and 50 years old; (ii) no previous history of stroke or myocardial infarction; (iii) no amputation or visual problems related to diabetes mellitus; (iv) no physical limitation that affects physical activity, and (v) either to be classified as persistently active (sport participation in both childhood and adolescence) or persistently inactive (no sport participation in both childhood and adolescence). At baseline, 122 participants fulfilled the inclusion criteria and were enrolled in the study. After 12 months of follow-up, there were 15 dropouts (14 participants declared no interest to continue participating in the study and one death [stroke; participant indicated no sport participation in early life]).

Diabetes markers

All blood sample collections and biochemical analyses were performed in a private laboratory, which meets the standardization criteria of quality control adopted by the Brazilian Health Ministry. A 12-h fasting blood sample collection was taken to measure fasting glucose, insulin and glycated hemoglobin (HbA_{1C}). Fasting values of glucose and insulin were used to calculate homeostatic model assessment-estimated insulin resistance (HOMA-IR). Numerical variables were categorized as normal or altered (fasting glucose ≥100 mg/dL; HOMA-IR ≥ 2.0 [18]; fasting insulin ≥ Percentile 75 [P75]; HbA_{1C} ≥ P75) in both moments of the study (baseline and follow-up). Therefore, for each diabetes markers, the participants were classified as follows: "no alteration in both moments", "alteration in just one moment," or "alteration in both moments". For statistical analysis, all diabetes markers were treated as normal (category "none alteration in both moments") and altered values in at least one moment of the study (categories "alteration in just one moment" and "alteration in both moments").

Early sport participation

Early sport participation was analyzed using two questions [7, 13, 19]: (i) "Outside school, have you ever been engaged in any organized/supervised sport activities for at least 1 year from 7 to 10 years old?" and (ii) "Outside school, have you ever been engaged in any organized/supervised sport activities for at least 1 year from 11 to 17 years old?" Other physical activities such as dance (e.g., ballet) were also included. Participants were classified as persistently active (sport participation in both childhood and adolescence) or persistently sedentary (no sport participation in both childhood and adolescence). Adequate levels of reproducibility for early sport participation have been previously reported [13].

Potential confounders

Chronological age, sex, skipping breakfast (outcome used in the multivariate model: skip breakfast at least 1 day per week at baseline), smoking habit (outcome used in the multivariate model: current smoker, former smoker, and new smoker during the follow-up), and alcohol consumption (outcome used in the multivariate model: the consumption of alcohol at least once week in both moments of the follow-up) were assessed through face-to-face interview. Resting systolic and diastolic blood pressure (SBP and DBP, respectively) were measured in a seated position after 10 min of rest (baseline measures was included in the multivariate models).

Whole body fatness was assessed using a Dual-Energy X-ray Absorptiometry (DEXA) scanner (Lunar DPX-NT; General Electric Healthcare, Little Chalfont, Buckinghamshire), with software version 4.7. The scanner quality was tested by a trained researcher prior to each day of measurement, following the manufacturer's recommendations. All measurements were performed at the university laboratory in a controlled temperature room. The participants wore light clothing, without shoes and remained in the supine position on the machine for approximately 15 min. The whole body fatness was expressed in percentage values, and baseline results were used as numerical variable in the multivariate models.

Current physical activity was objectively measured by pedometer (Digi-Walker Yamax, SW200) during a consecutive 7-day period. The device was fixed laterally at the hip and taken off only during periods of sleep, shower, and activities in pool. At the end of each day, the participants recorded the number of steps performed throughout the day. Every morning, to begin collecting data, the "reset" button was pushed to zero out the device. The mean values of steps in the week were assigned as the level of current physical activity, and the

Table 1 General characteristics of the sample involved in the longitudinal study (Brazil, $n = 107$)

Variables	Categories	Descriptive statistic (n = 107)	
		n (%)	(95%CI)
Sex	Male	64 (59.8)	(50.5–69.1)
	Female	43 (41.2)	(30.9–49.4)
Age (years)	<35	34 (31.8)	(22.9–40.6)
	35–44.9	49 (45.8)	(36.5–55.2)
	≥45	24 (22.4)	(14.5–30.3)
Early sport participation	No	55 (51.4)	(41.9–60.8)
	Yes	52 (48.6)	(39.1–58.1)
Skin color	White	88 (82.2)	(75.1–89.4)
	Black	08 (7.5)	(2.4–12.4)
	Others	11 (10.3)	(4.5–16.1)
Skipping breakfast	No	66 (61.7)	(52.4–70.8)
	Yes	41 (38.3)	(29.1–47.5)
Alcohol consumption	No in both moments	19 (17.2)	(10.5–25.1)
	At least once during follow-up	88 (82.8)	(75.1–89.4)
Smoking habit	No in both moments	82 (76.6)	(68.6–84.6)
	Former/at least once during follow-up	25 (23.4)	(15.3–31.3)
Glucose (≥100 mg/dL)	Normal in both moments	87 (81.3)	(73.9–88.7)
	Altered at least once during follow-up	20 (18.7)	(11.3–26.1)
HbA_{1c} (≥P75)	Normal in both moments	61 (57)	(47.6–66.3)
	Altered at least once during follow-up	46 (43)	(33.6–52.3)
HOMA-IR (≥2.0)	Normal in both moments	79 (73.8)	(65.5–82.1)
	Altered at least once during follow-up	28 (26.2)	(17.8–34.5)
Insulin (≥P75)	Normal in both moments	71 (66.4)	(57.4–75.3)
	Altered at least once during follow-up	36 (33.6)	(24.6–42.6)

sample was stratified as physically active (≥10,000 steps/day) or physically inactive (<10,000 steps/day) [14] in both moments of the follow-up. Finally, two numerical variables were created taking into account the number of days in which participants met cutoffs for physical activity (≥10,000 steps/day) and physical inactivity (≤5000 steps/day) at both baseline and follow-up. Therefore, two numerical variables ranging from zero (no days) to 14 (all days analyzed) were created, denoting physical activity (≥10,000 steps/day) and inactivity (≤5000 steps/day) during the follow-up period.

Statistical analysis

Numerical variables were presented as mean values and 95 % confidence intervals (95%CI), while categorical variables were presented as prevalence and 95%CI. Analysis of variance (ANOVA) for repeated measures compared numerical variables and sport participation in early life at baseline and end of follow-up. ANOVA for repeated measures was adjusted by potential confounders, while measures of effect size for each ANOVA parameter (time, early sport participation, and time × early sport participation) were identified by Eta-Squared values. Associations between categorical variables were expressed by the chi-square test (Yates' correction was applied in 2 × 2 contingence tables), while binary logistic regression provided measures of effect size (odds ratio [OR] and its 95%CI) of those associations. Hosmer-Lemeshow test was used to identify how fit was the multivariate models created by the binary logistic regression (p values >0.05 denotes adequate fit of the multivariate models). Pearson correlation and linear regression (adjusted by sex, age, and body fatness) denoted the relationship among numerical variables. Statistical significance (p value) was set at p value <0.05, and the statistical software BioEstat (release 5.0) performed all the analysis.

Results

One hundred and seven adults were followed during 12 months (11.7 ± 1.1 months [64 men and 43 women]). The sample was composed predominantly of participants with white skin (82.2 % [75.1–89.4 %]). Skipping breakfast was a habit reported by 38.3 % (29.1–47.5 %) of adults, while alcohol and smoking were habits reported (at least once during the follow-up period) by 82.8 and 23.4 % of the sample, respectively (Table 1).

Table 2 shows the relationship between current physical activity and diabetes markers according to early sports participation. Among adults with no engagement in sports during early life, there was a positive relationship between current physical inactivity and higher modification in glucose (β = 1.045 [95%CI, 0.267; 1.823]), insulin (β = 0.763 [95%CI, 0.121; 1.405]), and insulin resistance (β = 0.295 [95%CI, 0.062; 0.529]) independently of sex, age, and body fatness.

Figure 1 shows the estimated means of glycemic variables after 12 months of follow-up among adults stratified by early sport participation. Adults engaged in sports during early life had lower values of glucose in both moments of the study (p value = 0.029; Eta-squared = 0.049, small effect size). Compared to baseline values, glucose in follow-up decreased in adults with early sport participation (p value = 0.005; Eta-squared = 0.074, moderate effect size). HbA_{1c} slightly increased in both groups, but in both moments, adults with early sport participation presented lower values of HbA_{1c} (p value = 0.009; Eta-squared = 0.066, moderate effect size). Insulin resistance and fasting insulin values did not change during the follow-up period, but the values were lower in both moments among adults with early sports participation (Fig. 1).

There was an association between the lack of engagement in sports during early life and higher occurrence of altered values during the follow-up for insulin resistance (OR = 8.37 [2.10–33.3]) and insulin (OR = 7.61 [2.27–25.4] even when adjusted by potential confounders (Fig. 2). No association between early sport participation and altered values of glucose (p value = 0.110) and HbA_{1c} (p value = 0.265) were observed.

Discussion

This longitudinal study identified that adults who were engaged in sports during childhood and adolescence presented lower values of diabetes markers at baseline and during follow-up in comparison with adults with no history of sports participation. Additionally, the lack of sport participation in early life also affected the association between physical activity at adulthood and diabetes markers.

Our findings showed that participants who were engaged in sports during childhood and adolescence presented lower levels of diabetes markers (glucose, insulin resistance, and insulin) at baseline and after 12 months of follow-up in comparison with participants without history of sports participation. Similarly, Finnish former athletes when compared to their controls have better results in the impaired glucose tolerance test, as well as lower prevalence of diabetes mellitus and consumption of diabetes medicines [11].

Since diabetes is closely related with body fatness and physical inactivity, participants engaged in sports during early life are more likely to maintain this behavior throughout life [11, 20]. Moreover, sport participation has been associated with higher energy expenditure in other domains of physical activity, such as leisure-time physical activity (moderate-to-vigorous intensity) and less sedentary behavior in youth [21]. All these aspects could help to preserve lower body fatness values throughout life (mainly during the growth spurt in adolescence) and normal function of glucose and insulin (no imbalance) [11].

The increasing prevalence of physical inactivity in pediatric populations constitutes a worldwide concern and it is not restricted to developed nations [22]. Our findings show relevant effect of physical inactivity in early life on harmful health outcomes in adulthood. These results reiterate the necessity of public policies promoting physical activity among children and adolescents, since being physically active only in

Table 2 Relationship between current physical activity and glycemic variables according to early sport participation (Brazil, n = 107)

Sport participation in childhood and adolescence	Glucose (mean difference) r (95%CI)	HbA_{1c} (mean difference) r (95%CI)	HOMA-IR (mean difference) r (95%CI)	Insulin (mean difference) r (95%CI)
No (n = 55)				
<5000 steps/day**	0.295 (0.035; 520)	0.031 (−0.236; 0.294)	0.293 (0.030; 0.518)	0.295 (0.032; 0.520)
Linear regression	β = 1.045 (0.267; 1.823)*	–	β = 0.295 (0.062; 0.529)*	β = 0.763 (0.121; 1.405)*
≥10,000 steps/day** linear regression	−0.119 (−0.373; 0.151)	−0.007 (−0.272; 0.259)	−0.120 (−0.373; 0.150)	−0.112 (−0.366; 0.158)
Yes (n = 52)				
<5000 steps/day** linear regression	−0.050 (−0.319; 0.226)	0.087 (−0.190; 0.352)	−0.188 (−0.438; 0.089)	−0.202 (−0.450; 0.075)
≥10,000 steps/day** linear regression	−0.134 (−0.393; 0.144)	−0.067 (−0.334; 0.210)	−0.106 (−0.368; 0.172)	−0.101 (−0.364; 0.177)

95%CI = 95 % confidence interval

*linear regression adjusted by sex, age, body fatness percentage and changes in body fatness percentage

**sum of days meeting that cut-off in both moments of analysis (baseline and follow-up)

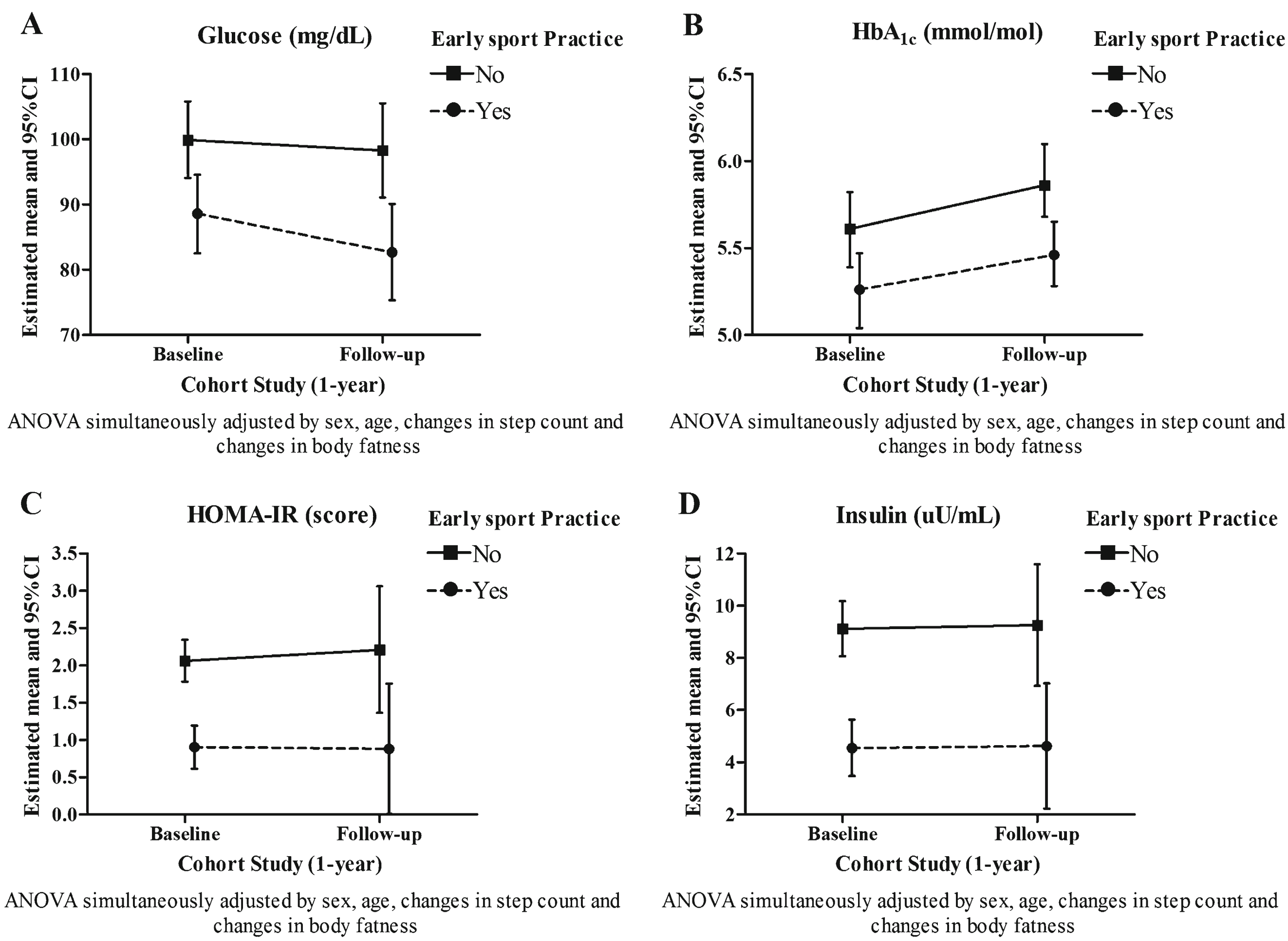
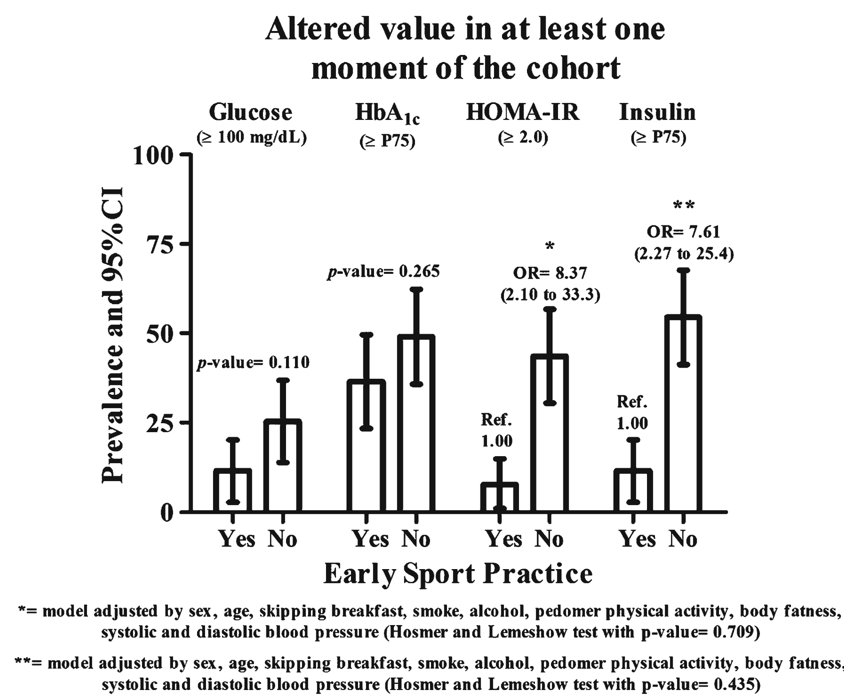


Fig. 1 Estimated means (ANOVA for repeated measures) of glycemic variables after 12 months of follow-up stratified by early sport participation (Brazil, n = 107)

Fig. 2 Associations between altered values of glycemic parameters and sport participation in early life during the follow-up (Brazil, n = 107)



adulthood is apparently not enough to guarantee good metabolic health.

Additionally, sports participation in childhood and adolescence affected the relationship between current physical activity and diabetes markers, in which lower levels of physical activity in adulthood were related to diabetes markers only in participants with no engagement in sports during early life. Epigenetic pathways have been proposed to support these findings [7, 23]. During critical periods of human life, behavioral and environmental agents can induce epigenetic variations and thereby permanently affect metabolism, increasing the risk of development of diseases [23]. It is known that physical activity in early life promotes good health not only during childhood and adolescence, but also in the subsequent years (adulthood), and it happens because these two periods of life are characterized by higher sensitivity to epigenetic modifications [7, 8, 19, 23]. In fact, sport participation during childhood and adolescence affects gene polymorphisms/expression, as well as DNA methylation in adulthood [12, 24]. Under these circumstances, it is possible to consider that adults who were active during early life are less likely to experience harmful metabolic events preceding the development of diabetes.

Limitations should be highlighted. Considering that the maintenance of physical activity is not constant, its instability should be taken into account [25]. Moreover, participants recalled sport participation in childhood (7–10 years old) and adolescence (11–17 years old) and recall bias cannot be completely excluded. About the longitudinal analyses, longer periods of follow-up would be more appropriate to analyze the interaction between glycemic variables and early sport participation. Finally, the absence of worldwide-accepted cutoffs to HOMA-IR is a limitation, which deserves to be mentioned due to its possible impact on the observed associations.

In summary, it is possible to conclude that the engagement in sport activities during early life affects glycemic variables in adulthood, as well as longitudinal relationship between physical activity in adulthood and glycemic control, seems affected by early sport participation as well.

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Compliance with ethical standards The authors would like to declare the following: (i) this study received no funding resources; (ii) there is no conflict of interest in the realization of this study; and (iii) all ethical procedures related to human research were strictly followed by the research team in all steps of the study.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The authors declare that all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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