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Fitness, cardiovascular and metabolic risk factors: A correlational study

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ORIGINAL ARTICLE

ABSTRACT

This study aimed to verify the relationship between anthropometric measures (AM), blood pressure (BP) and cardiorespiratory fitness (CRF), physical activity (PA), sedentary behaviour (SB), predicted BMI z-score, waist circumference (WC) and waist-to-height ratio (WHtR) variance. A total of 245 children (8.90 ± .80years-old) were recruited from a Portuguese school. WHtR was classified according the reference ≥ 0.5. WC was measured above iliac crest. BP was assessed using a sphygmomanometer, and CRF using 20-m run test. PA and SB were assessed by accelerometers (Actigraph GT3x) and by questionnaire. Participants did not meet recommendations on PA. CRF and vigorous PA (VPA) were inversely correlated with AM. Moderate and vigorous PA were positively correlated with CRF. CRF was inversely correlated with systolic and diastolic BP. CRF and PA explained BMI z-score variance. WC and WHtR variance was predicted by CRF. These results emphasize the importance of international recommendations for PA with the purpose of developing CRF. A new emphasis should be given to CRF and interdisciplinary approaches in international recommendations. This should provide new health implications for primary care providers and school services.

Keywords: Fitness, physical activity, sedentary behaviours, blood pressure, children.

INTRODUCTION

Physical inactivity is a primary cause of pathological and clinical conditions such as the loss of functional capacities with chronological aging, metabolic syndrome, obesity, insulin resistance, prediabetes/type 2 diabetes, non-alcoholic liver disease, cardiovascular diseases, cognitive functions and diseases, bone and connective tissue disorders, cancer, reproductive diseases, and diseases of digestive tract, pulmonary, and kidney (Booth, Roberts, & Laye, 2012). These processes are related to the presence of cardiovascular disease risk factors: age, gender, diet, physical inactivity, high blood pressure (BP), and overweight/obesity (Daniels et al., 2012). In addition, evidences showed relationships between increases in moderate-to-vigorous physical activity (MVPA), and decreases in systolic and diastolic blood pressure (SBP and DBP), decreases in body fat and body mass index (BMI), and improvements in fitness measures in childhood and adolescence (Daniels et al., 2012).

The dose-response association between PA and health benefits indicated that more PA is needed for increasing health benefits (Janssen & Leblanc, 2010). Considering their higher impact on cardiorespiratory fitness (CRF), vigorous activities and muscle and bone strengthening activities have been highlighted in many international recommendations on PA for Health (Tremblay et al., 2016; World Health Organization [WHO], 2010).

A longitudinal study showed a clustering of cardiovascular disease risk factors highly associated with a low fitness level at the age of six and nine years old (Andersen, Bugge, Dencker, Eiberg, & El-Naaman, 2011). Moreover, higher PA levels were consistently associated with an improved metabolic profile

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and a reduced risk for metabolic syndrome and/or insulin resistance (IR) (Guinhouya, Samouda, Zitouni, Vilhelm, & Hubert, 2011). Inverse associations between obesity and PA were also highlighted (Ferrari et al., 2015; Nemet, 2016). Among normal weight youth, those with relatively high levels of PA tend to have less adiposity than youth with low PA levels (CDC, 2008). However, there were evidences that a large proportion of children did not met the PA recommendations and exhibited prolonged sedentary behaviours (SB) (Verloigne et al., 2012), leading to an increased concern about the time spent in a sedentary behaviour ('sitting time'), especially with the development of attractive home-based electronic entertainment (Biddle, O'Connell, & Braithwaite, 2011). This constellation of obesogenic factors resulted in an increase from 8.1% to 12.9% in boys, and from 8.4% to 13.4% in girls of the overweight and obesity in developed countries (Ng et al., 2014).

Obesity has become a major global health challenge (Ng et al., 2014) especially during childhood since it affects social and emotional health and school performance (Sahoo et al., 2015). Given these facts, paediatric obesity was associated with the increased rate of premature death due to endogenous causes (Franks et al., 2007).

Although the overwhelming scientific evidences about physical inactivity as a primary cause of most chronic diseases, it has been largely ignored and prioritized as low (Booth et al., 2012). However, there are known gaps in the literature, specifically with regard to the prediction and association between cardiovascular and metabolic risk factors or risk reduction in childhood and clinical events in adult life (Daniels et al., 2012). Thus, from primary prevention perspective, the study of the prevalence of several variables related to cardiovascular disease at early ages has become very important. In the absence of personal or family history with conditions that increase risk, cardiovascular risk assessment should begin at the age of 9 years old or before (Juonala et al., 2010), allowing for early interventions, that can be merged with the day-to-day of the children (e.g., in schools). Therefore, this study focused in several variables related to cardiovascular and metabolic risk factors at early ages, in a school setting, using many covariates such as gender, age, and socioeconomic status, in a geographic region that was seldom studied.

To the best of our knowledge, predictions of anthropometric measures (AM) such as BMI z-score, waist circumference (WC), waist-to-height ratio (WHtR), and BP, considering PA and CRF, and SB combining self-reports and objective data in children, have not been studied in depth. This research aimed to analyse AM, CRF, PA, SB, and BP according gender, age, and socioeconomic status (SES) and to explore the association between AM and BP with CRF, PA and types of SB. Furthermore, we aimed to predict BMI z-score, WC and WHtR through the aforementioned variables. It was hypothesized that PA, CRF, and SB would be important predictors of all AM and that strong inverse correlations would be found between PA, CRF, and SB with AM and with BP.

METHOD

Participants

A total of 245 children (7-11 years; 8.90 ± 0.80 years old; 111 girls: 45.1%) were recruited from a convenience sample of a primary urban school. First, after the approvals to conduct this research, the school introduced the study into its annual activity plan. Later, it was presented to teachers, participants and legal guardians of each class to achieve the necessary sample. All participants and their legal guardians were provided with an informed consent form. The participants eligible for the study must be between 7 and 10 years old (inclusively) and participants and legal guardians signed the informed consent forms. Exclusion criteria were: i) disabilities or severe motor handicaps; ii) relevant health problems; iii) incapacity to perform all the tasks involved in the study.

Participant's age was divided into: 7–8, 9 and 10–11. SES was also categorized (low, average and high) according parent's employment circumstances/annual income. This cross-sectional study, was the first stage of a larger investigation. The second stage was a randomized controlled trial in children with cardiovascular and metabolic risk factors previously identified.

Measures and Procedures

The researchers assessed all variables during school activities and recess periods in a prepared classroom. The teachers organized their students in small groups for the assessments. After the data collection, a meeting with the legal guardians was held to fill questionnaires and to report on the results of the previous measures.

The height was measured with a stadiometer (Seca 206), body weight was measured using the Omron BF511T. BMI z-score was calculated because is the most widely used and recommended measure to estimate weight status in these age groups. Overweight and obesity status were determined (WHO, 2007). WC was measured above the iliac crest, and classified (Fernández, Redden, Pietrobelli, & Allison, 2004). WHtR was calculated as the ratio of waist and height and was classified according the reference value of ≥ 0.5 (Nambiar, Hughes, & Davies, 2010). This is a useful measure to identify children with higher body fat percentage at greater risk of developing weight-related cardiovascular disease at an earlier age.

For BP, three measurements were taken using a digital sphygmomanometer (Hartmann Tensoval Duo Control). Standardized procedures were performed. An appropriate sized cuff was placed after 5 minutes rest. The mean value of second and third measurements was calculated.

CRF, as the major predictor of functional capacity (Booth et al., 2012), was assessed using the 20-m shuttle run test. VO_2max was estimated using Fernhall et al.'s (Fernhall et al., 1998) and Matsuzaka et al.'s (Matsuzaka et al., 2004) models.

PA and SB were measured through accelerometers (Actigraph GT3x) over 5 days, 3 weekdays and 2 weekend days. A wear time validation criterion was applied, corresponding to 10 hours wearing periods during weekdays (Cain, Sallis, Conway, Van Dyck, & Calhoon, 2013; Rich et al., 2013). On weekends, a criterion of 8 hours periods was used. Included data had a minimum of 10 hours wearing time in two weekdays and a minimum of 8 hours-wearing time in one of the weekend days. The 10 seconds epoch was used to assess short duration PA (Kelli & Cain, 2014). Minutes per day of SB, light PA (LPA), moderate (MPA) and vigorous (VPA) was estimated (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008; Trost, Loprinzi, Moore, & Pfeiffer, 2011).

The importance of combining self-reports and objective data to examine associations with specific SB in the contexts within which they occur was considered (Pulsford et al., 2011). Self-reports provide important behaviour-specific estimates of sedentary time, such as social activities and technologically-oriented SB (Biddle et al., 2011). An adapted version of the Adolescent Sedentary Activity Questionnaire (ASAQ) was also administered to the children's parents (Hardy, Booth, & Okely, 2007).

Statistical Analysis

In statistical analysis a significance level of set for $p<0.05$. ANCOVA was used for comparative analysis (gender, age and SES as covariates). Effect sizes were expressed as partial et squared (.01 = small, .06 = medium, and .14 = large effect) (Lakens, 2013; Pallant, 2007). Pearson correlations were performed to evaluate the strength of relationships. Correlation coefficients were classified according to Cohen's criterion (small = .10; medium = .30; large = .50) (Cohen, 1998). The R^2 was used for the correlations's effect size (Field, 2009). A hierarchical linear regression was carried out to identify AM predictors. A forced entry was used to control for age and SES, followed by the stepwise method to select potential predictor variables.

RESULTS

Descriptive statistics, as well as comparative analysis of AM, CRF, PA, SB and BP according to gender and age are presented in Table 1.

The sample comprised 50.2% normal weight children, 29.8% with overweight status and 20% with obese status. A total of 76.7% children had normal WC. The prevalence of children with a high WC was 23.3%.

Table 1

Comparative analysis of anthropometric measures, cardiorespiratory fitness, physical activity, sedentary behaviours and blood pressure according to gender and age.

	Boys a) (N = 134)	Girls a) (N = 111)				Age (7-8 y) b) (N = 72) 1)	Age (9 y) b) (N = 119) 2)	Age (10-11 y) b) (N = 54) 3)			
	Mean ± SD	Mean ± SD	F	η_p^2	p	Mean ± SD	Mean ± SD	Mean ± SD	F	η_p^2	p
BMI z-score	1.01 ± 1.22	.75 ± 1.17	2.954	0.012	0.087	.82 ± 1.11	1.05 ± 1.18	.63 ± 1.34	2.661	0.022	0.072
WC (cm)	66.86 ± 9.53	67.02 ± 9.15	0.386	0.002	0.535	63.78 ± 7.49 $^{1<2,3}$	68.36 ± 9.39 $^{2>1}$	67.98 ± 10.54 $^{3>1}$	5.961	0.047	0.003
WHtR	.49 ± .06	.49 ± .08	0.107	0.000	0.744	.48 ± .07	.50 ± .06	.48 ± .065	1.543	0.013	0.216
CRF (Fern)	45.24 ± 5.60	38.72 ± 4.61	91.244	0.275	<0.001	40.71 ± 4,88	42.37 ± 6.61	44.10 ± 5.94	2.589	0.021	0.077
CRF (Mats)	46.34 ± 4.56	45.09 ± 4.18	5.471	0.023	0.017	46.18 ± 3.52	45.43 ± 4.84	45.98 ± 4.58	.750	0.006	0.473
LPA (m/day)	222.07 ± 41.55	227.75 ± 39.75	0.496	0.002	0.466	234.14 ± 39.90	223.57 ± 38.37	217.19 ± 45.38	2.268	0.021	0.106
MPA (m/day)	38.34 ± 12.36	29.29 ± 9.79	34.168	0.140	<0.001	32.50 ± 10.05	34.76 ± 12.62	34.05 ± 12.85	0.473	0.005	0.624
VPA (m/day)	20.83 ± 11.31	14.23 ± 8.60	23.049	0.099	<0.001	17.05 ± 9.07	18.19 ± 10.47	17.25 ± 12.51	0.545	0.005	0.580
SB (m/day)	509.87 ± 90.60	503.18 ± 70.57	0.005	0.000	0.945	490.35 ± 69.68	500.94 ± 83.53 $^{2>1}$	537.72 ± 82.46 $^{3>1}$	4.875	0.045	0.009
SSR (m/day)	135.36 ± 88.80	120.57 ± 60.04	1.226	0.007	0.270	115.61 ± 84.99	123.61 ± 61.00	157.11 ± 96.86	3.223	0.036	0.042
Educ (m/day)	57.98 ± 26.37	61.67 ± 32.71	1.002	0.006	0.318	50.01 ± 20.85	61.04 ± 29.73	63.54 ± 36.92	1.386	0.016	0.253
CA (m/day)	78.46 ± 58.04	73.68 ± 46.44	0.201	0.001	0.654	60.04 ± 56.45	82.20 ± 55.76	73.47 ± 37.8	1.382	0.016	0.254
SA (m/day)	52.89 ± 46.03	51.94 ± 36.77	0.010	0.000	0.922	52.25 ± 42.93	51.84 ± 42.65	54.40 ± 38.79	0.27	0.001	0.973
Trav (m/day)	32.88 ± 29.32	26.77 ± 19.84	1.460	0.012	0.229	29.86 ± 27.07	29.67 ± 24.98	29.43 ± 23.67	0.72	0.001	0.930
SBP (mmHg)	95.53 ± 8.85	95.92 ± 8.98	0.042	0.000	0.838	94.88 ± 8.00	96.40 ± 9.22	97.76 ± 9.19	1.475	0.012	0.233
DBP (mmHg)	61.88 ± 8.02	62.11 ± 7.49	0.276	0.001	0.600	60.42 ± 6.58	62.69 ± 8.50	62.51 ± 7.37	2.065	0.017	0.129

Note. a) Covariates: age and socioeconomic status (SES); Note. b) Covariates: gender and socioeconomic status (SES)

SD: Standard deviation; m: minutes; BMI: Body mass index; WC: Waist circumference; WHtR: Waist-to-height ratio; CRF: Cardiorespiratory fitness (Fern: Fernhall; Mats: Matsuzaka); LPA: Light physical activity; MPA: Moderate physical activity; VPA: Vigorous physical activity; SB: Sedentary behaviour; SRR: Small screen recreation; Educ.: Education; CA.: Cultural Activities; SA: Social Activities; Trav.: Travel; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; η_p^2: Partial Eta Squared

More than half of the participants (58.8%) had a WHtR smaller than 0.5 and 41.2% larger than 0.5. In the BMI z-score, no differences were found between the age tertiles. There were differences in WC according age, indicating higher values in the second and third tertiles when compared to the first one ($F_{(2,240)} = 5.96$, $p = 0.003$; $\eta_p^2 = 0.047$).

In WHtR, no differences were found between genders and age. The boys had higher levels of CRF in both models. The size effect was large for the Fernhall et al. (1998) model and small for the Matsuzaka et al. (2004) model.

Participants did not met recommendations of 60 minutes of MVPA per day. Regarding LPA, after controlling for age and SES, no differences were found between genders. In other PA levels, boys presented higher levels of MPA and VPA (no significant covariates, effect size was large for MPA and medium for VPA). No differences were found in intensity PA levels between ages. In SB, results showed that participants spent more than eight hours per day in SB. Controlling for age, no differences were observed among boys and girls in total time SB (min/day). Age (as a covariate) was associated to SB ($F_{(1,210)} = 8.32$, $p = 0.004$, $\eta_p^2 = 0.038$). Older participants (9y and 10–11y) spent more time per day in SB than younger ones (none of the covariates were statistically significant in this analysis). The ANCOVA on self-reported SB, showed no differences between boys and girls. Comparing age tertiles, a significant difference was only observed in the small screen recreation ($F_{(2,174)} = 3.22$, $p = 0.042$; $\eta_p^2 = 0.036$). No differences were observed for time spent in other activities (education, cultural and social activities). No significant differences were found in gender and age tertiles for SBP and DBP.

Pearson analysis showed a significant correlation between CRF and all AM (Table II), indicating the presence of a negative relationship between CRF (both models) and BMI z-score, WC, and WHtR. The CRF (Fernhall et al.'s model) shared 30.7% of BMI z-score variability, 36.0% of WC variability, and 29.7% of WHtR variability. The CRF (Matsuzaka et al.'s model) shared 70.1% of BMI z-score variability, 73.6% of WC variability, and 56.3% of WHtR variability.

Table 2
Pearson correlation between anthropometric measures and blood pressure with cardiorespiratory fitness, physical activity and types of sedentary behaviour.

	BMI z-score		WC		WHtR		SBP		DBP	
	r	p	r	p	r	p	r	p	r	p
CRF (Fern)	-0.554	<0.001	-0.600	<0.001	-0.545	<0.001	-00.194	0.002	-0.111	0.083
CRF (Mats)	-0.837	<0.001	-0.858	<0.001	-0.750	<0.001	-0.325	<0.001	-0.177	0.005
LPA (min)	-0.036	0.605	-0.080	0.241	-0.005	0.941	0.013	0.847	0.100	0.144
MPA (min)	-0.043	0.533	-0.101	0.142	-0.089	0.196	-0.037	0.591	-0.063	0.356
VPA (min)	-0.202	0.003	-0.242	<0.001	-0.216	0.002	-0.105	0.127	-0.107	0.118
SB (min)	-0.079	0.251	-0.010	0.879	-0.026	0.710	0.043	0.529	-0.032	0.638
SSR (min)	0.006	0.936	0.061	0.417	0.041	0.585	-0.027	0.679	-0.069	0.282
Educ (min)	0.127	0.088	0.158	0.035	0.129	0.085	0.070	0.277	-0.017	0.787
CA (min)	0.043	0.499	0.067	0.294	0.062	0.331	0.055	0.395	-0.070	0.274
SA (min)	0.050	0.615	0.024	0.807	0.045	0.649	-0.029	0.656	-0.055	0.395
Travel (min)	0.108	0.238	0.092	0.315	0.004	0.967	0.090	0.322	0.053	0.557

BMI: Body mass index; WC: Waist circumference; WHtR: Waist-to-height ratio; CRF: Cardiorespiratory fitness (Fern: Fernhall; Mats: Matsuzaka); LPA: Light physical activity; MPA: Moderate physical activity; VPA: Vigorous physical activity; SB: Sedentary behaviour; SRR: Small screen recreation; Educ.: Education; CA.: Cultural Activities; SA: Social Activities; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

Similar results were verified between CRF (Fernhall et al.'s model) and SBP, albeit with a weaker relation (CRF shared only 3.8% of SBP variability). The CRF (Matsuzaka et al.'s model) was also inversely correlated with both SPB (medium relation) and DBP (weaker relation), sharing 10.6 of SBP variability, and 3.1% of DBP variability. Considering the associations between PA and AM, only VPA was negatively correlated with BMI z-score, WC, and WHtR (a weak relationship). VPA shared 4.1% of the variability in BMI z-score, 5.9% of the variability in WC, and 4.7% of the variability in WHtR.

There was found a positive correlation between CRF and MPA (r (245) = 0.39, p <

0.001), as well as between CRF and VPA (r (245) = 0.31, $p < 0.001$, both reflected a medium correlation). MPA shared 15.2% of CRF variability and VPA shared 9.6%. Neither total time spent in SB, nor its different activities were correlated with AM or BP. The exception was the positive correlation between education-related SB and WC.

No correlations were found between CRF and SB. A negative correlation was found between CRF and the mean of time spent in SB education-related activities (Fernhall et al.'s model: r (180) = -0.12, p = 0.019; Matsuzaka et al.'s model: r (180) = -0.13, p = 0.009). A positive correlation (medium relation) was observed between SBP and BMI z-score (r (245) = 0.35) and WC (r (245) = 0.39). The positive correlation between SBP and WHtR was weaker (r (245) = 0.29, all $p < 0.001$). Similar results were found for DBP (BMI z-score (r (245) = 0.16, WC (r (245) = 0.20), and WHtR (r (245) = 0.160), all $p \leq 0.012$). All the observed r-values were weaker.

Regression models are presented in Table III. CRF (Fernhall et al.'s model), PA, the age and SES covariates explained 38.8% of the BMI z-score variance. Only MPA presented a positive coefficient (0.138).

Table 3

Prediction of BMI z-score, WC and WHtR variance.

	BMI z-score			WC			WHtR		
	β-coefficient	p	R Square Change	β–coefficient	p	R Square Change	β-coefficient	p	R Square Change
Age / SES	-0.039 / -0.071	0.018	0.037	0.265/-0.061	0.060	0.026	0.127/-0.075	0.184	0.016
CRF (Fern)	-0.593	<0.001	0.312	-0.676	<0.001	0.427	-0.568	<0.001	0.301
VPA	-0.276	0.026	0.015	-----	-----	-----	-----	-----	-----
LPA	-0.183	0.004	0.024	-----	-----	-----	-----	-----	-----
MPA	0.432	0.019	0.017	-----	-----	-----	-----	-----	-----
Total	-----	-----	38.8 %	-----	-----	44.5 %	-----	-----	30.7 %
	BMI z score			WC			WHtR		
	β -coefficient	p	R Square Change	β–coefficient	p	R Square Change	β–coefficient	p	R Square Change
Age / SES	-0.103 / -0.009	0.018	0.037	0.141/-0.001	0.060	0.026	0.024/-0.022	0.184	0.016
CRF (Mats)	-0.860	<0.001	0.689	-0.869	<0.001	0.739	-0.741	<0.001	0.537
MPA	0.112	0.002	0.012	-----	-----	-----	-----	-----	-----
Total	-----		73.3 %	-----	-----	76.5 %	-----	-----	55,3 %

BMI: Body mass index; WC: Waist circumference; WHtR: Waist-to-height ratio; SES: Socioeconomic status; CRF: Cardiorespiratory fitness (Fern: Fernhall; Mats: Matsuzaka); LPA: Light physical activity; MPA: Moderate physical activity; VPA: Vigorous physical activity.

Age and CRF (Fernhall et al.'s model) explained 44.5% of the WC variance and 30.7% of the WHtR variance. Considering the Matsuzaka et al.'s model, CRF, MPA (also with positive coefficient), age and SES explained 73.3% of the BMI z-score variance. The age, SES and the CRF explained 76.5% of the WC variance and 53.3% of the WHtR variance.

DISCUSSION

In an attempt to better understand several variables associated with the early development of cardiovascular and metabolic risk factors in youth, our purpose was to study the relationship between AM and BP with PA, CRF and SB. Furthermore, the study aimed to predict BMI z-score, WC and WHtR taking the aforementioned variables into consideration. The hypothesis that suggested PA, CRF, and SB as important predictors of all AM, as well as, strong inverse correlations between PA, CRF, and SB with AM and with BP, were partially confirmed. The predictive power of CRF and inverse correlations with AM and BP were confirmed. The predictive power of PA and inverse correlations with AM were confirmed. However, the predictive power and inverse correlations of SB were not confirmed. CRF (Fernhall et al.'s model), LPA, MPA, and VPA along with the covariates age and SES explained 38.8% of the BMI z-score variance. Moreover, WC and WHtR variance was only explained by

CRF. Higher values for CRF (Matsuzaka et al.'s model) predicted a higher BMI z-score, WC, and WHtR variance. CRF was inversely correlated with BMI z-score, WC, and WHtR, and only VPA was inversely correlated with BMI z-score, WC, and WHtR. MPA and VPA was positively correlated with CRF. Positive correlations between SBP and DBP and all AM were found. Equally important was the inverse correlation between CRF (Matsuzaka et al.'s model) and SBP and DBP.

Our results showed that BMI z-score, WC and WHtR variance was explained by CRF, thus confirming the importance of the current PA recommendations which focus on developing CRF (CDC, 2011). Considering overweight/obesity and their relationship with cardiovascular disease risk factors in childhood, CRF may have an independent protective influence on a subsequent increase in cardiovascular risk (Eisenmann, Welk, Wickel, & Blair, 2007). These results highlight the importance of global approaches considering both fatness and aerobic fitness when cardiovascular risk factors in children are studied (Kolsgaard et al., 2012). This is also in agreement with previous longitudinal reports (Andersen et al., 2011). Perhaps, the greater predictive power of BMI z-score, WC, and WHtR variance verified when Matsuzaka et al.'s model was included in linear regression can be justified by the VO_2max estimation equation used when compared with the Fernhall et al.'s model. In both models, BMI, gender and pacer laps are included, but only Matsuzaka et al.'s model included age, and at such young ages the development factors may play a larger role.

For BMI z-score variance, only MPA had a positive coefficient, thus reflecting higher BMI z-scores in association with higher MPA, a result that appears controversial. This may be explained by the low amount of MPA per day (in opposition to the large amount of LPA which was the most common intensity of participants' PA; see Table I). We suggest that in our study LPA is important because of its amount. This has already been suggested before as LPA seems to have some beneficial effect on adiposity among older children, but little to no effect among younger children (Kwon, Janz, Burns, & Levy, 2011). We recognize that several cross-sectional studies showed no relationship between time performing LPA and BMI (Byrd-Williams, Kelly, Davis, Spruijt-Metz, & Goran, 2007; Hughes, Henderson, Ortiz-Rodriguez, Artinou, & Reilly, 2006; Thompson et al., 2009; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006).

VPA seems to be relevant not only because of the amount but also because of the intensity. Considering the different metabolic equivalents commonly used to express the intensity of PA, MPA does not have the same cardiovascular and metabolic effects, when compared with VPA, and therefore possibly has a smaller positive effect on the BMI z-score (WHO, 2010).

Children with obesity did less VPA when compared with overweight and normal weight children. Children with obesity may not have enough CRF to perform a lot of VPA. But even this small amount of VPA appeared to be sufficient to be associated with lowers BMI z-scores. The inverse correlations between VPA or CRF and BMI z-score, WC and WHtR, as well as the positive correlations between MPA and VPA and CRF, are consistent with international recommendations that suggest at least 1 hour of MVPA every day of the week, with VPA on at least three of those days (WHO, 2010). It seems that PA intensity is an important variable, even if VPA duration and weekly frequency is not high.

A higher intensity of PA achieved at these ages is relevant because it can cause a significant impact on variables associated with the cardiovascular and metabolic profile, namely, CRF and BMI z-score, WC, and WHtR. In fact, evidence has substantially supported these associations (Ferrari et al., 2015; Nemet, 2016). In children from many countries, greater MVPA and VPA were both associated with lower odds of obesity, independently of SB (Nemet, 2016). An increase in MVPA is associated with lower SBP and DBP, decreased measures of body fat, decreased BMI and improved fitness measurements in childhood (Thompson et al., 2009). An important systematic review concluded that it is possible to achieve improvements in CRF with exercise training at intensities greater than 80% of maximal heart rate, at a frequency of 3 to 4 days per week, for a duration of 30 to 60 minutes per session over the course of 1 to 3 months (CDC, 2008). PA is associated with numerous health benefits and to achieve substantial health benefits, school-aged children and youth should performed PA at a moderate intensity, at least, and it should be recognized that vigorous activities may provide even greater benefits (Janssen & Leblanc, 2010).

Analysing PA according to gender showed higher levels of both MPA and VPA in boys, a finding in agreement with previous research (Verloigne et al., 2012). As expected, boys showed a higher level of CRF. Some recommendations have focused on the importance of more effective interventions in girls since they tend to spend less time doing PA. In the same study, the authors concluded that girls spent significantly less time on LPA (267 minutes/day) and MVPA (32 minutes/day) than boys (284 minutes/day and; 43 minutes/day, respectively). Our results confirmed that Portuguese girls appear to have PA behaviour identical to girls from other European countries.

Nevertheless, as in previous studies, the participants of this study did not engage in 60 minutes of daily MVPA. In a previously referenced study dedicated to the levels of PA and SB among 10-to-12-year-old European boys and girls, author concluded that a large proportion of children did not meet PA recommendations (Verloigne et al., 2012). Considering the several health and academic performance benefits of PA (CDC, 2011) and the growing problem of childhood obesity caused by energy deficit-related behaviours, these results are worrisome. However, in this study the children were advised to remove the accelerometer in many sports, such as in swimming, in aquatic sports and others that could damage the device. This procedure may help explain why the children did not meet PA recommendations because sports participation normally provides more vigorous activities, and these sport activities (i.e., swimming, soccer) are available in the region where the study was held.

Regarding SB, no correlations were found between types and total time spent in SB and anthropometric measures or BP, except between behaviours related to education and WC. Similar results were observed within the framework of the National Health and Nutrition Examination Surveys, where no association was also observed between overall volume and patterns of SB with cardio-metabolic risk factors in children and adolescents (Carson & Janssen, 2011). Our results showed that children spent more than 8 hours per day in SB. Contrary to the results of other studies, in our sample girls did not spend more time in sedentary activities compared to boys (Verloigne et al., 2012).

The total time spent in SB did not explain the variance in AM. Academic performance, in fact, is substantially focused on mathematics and portuguese language in the classroom. Therefore, the environmental context of Portuguese schools seems to promote many sedentary educational activities as the predominant activity at school is sitting in class. It is known that an increased sedentary time is associated with negative health outcomes in both boys and girls (Tremblay et al., 2011). Works focusing on the relationship between SB and body composition have shown that more than two hours of SB was related to an increased risk of being overweight or obese. Results concerning the relation between SB and metabolic syndrome or cardiovascular disease markers have shown that more than two hours of screen time per day was associated with higher blood pressure and an increased risk for metabolic syndrome. Longitudinal studies concluded that more than 1.2 hours of TV per day is associated with increased SBP. Contemporary youths watch 1.8–2.8 hours/day of television, with 28% watching more than 4 hours/day. In this report, total screen time averaged 2.7–4.3 hours/day (Marshall, Gorely, & Biddle, 2006). In our study, age was associated with SB. Older children (9 and 10–11 years of age) spent more time per day in SB than younger ones (7–8 years of age). Perhaps, small screen recreation time can be associated with total time SB (7–8 years of age, 115.61 min/day ± 84.99; 9 years of age, 123.61 min/day ± 61.00; 10–11 years of age, 157.11 min/day ± 96.86).

Our results indicated that in children the harmful health effects caused by SB are not as evident as in other ages. In adults, physical inactivity is now identified as the fourth leading risk factor for global mortality (WHO, 2010). PA and diet may partly explain these results, and may represent confounding factors that lead to an increase in energy deficit-related behaviour. Television watching may not be a good marker of SB in children because the relationships observed between television watching, obesity, and metabolic risk may be confounded or mediated by other behaviours, such as snacking while watching television (Steele, Brage, Corder, Wareham, & Ekelund, 2008).

Positive correlations found between SBP and DBP and all AM are in agreement with other studies (Baker, Farpour-Lambert, Nowicka, Pietrobelli, & Weiss, 2010). Obesity in children and adolescents is associated with numerous immediate health risks, including high BP.

Considering that in Portugal as in many other countries, primary health care providers, including paediatricians, family practitioners, dieticians, and nurses supervise the majority of overweight or obese children and school health services, these findings should provide an additional interdisciplinary tool. Due to the lack of training of many primary health care providers on PA recommendations for children, interventions usually are focused on calorie intake and food habits. Insufficient feedbacks are dedicated to PA, CRF, and SB. In this context, increased PA and decreased SB could be very helpful because energy expenditure is an important part of the energy balance equation that determines body weight (Baker et al., 2010).

Limitations and Strengths

The findings from the present study should be considered together with some limitations. Our sample is not nationwide representative because all participants were only recruited from one Portuguese school. More detailed approach in SB analysis is suggested, including bouts and breaks for this type of behaviour. The sample size can be regarded as one of the strengths of the study. We suggest the replication of this study in other samples in different contexts. Other strengths are the inclusion of different AM and its assessment carried out by the same researcher. PA and SB patterns objectively measured through accelerometers helped to reduce measurement error.

CONCLUSIONS

In summary, our findings indicated a higher percentage of BMI z-score, WC and WHtR variance explained by CRF. Only VPA was inversely correlated with BMI z-score, WC, and WHR. VPA and MPA were positively related with CRF. Even at early ages, the predictions and associations found emphasized the importance of current international recommendations for PA with the specific purpose of developing CRF and potentially prevent health problems. Probably, a new emphasis should be given to the development of CRF. Effective interdisciplinary approaches in international recommendations should be developed in order to protect children's health. This should provide new public implications for primary health care providers, school health services, and physical education teachers. No associations were found between main SB and anthropometric measures, CRF or BP. Therefore, these data seem to suggest that harmful health effects caused by SB do not occur as in later ages. Due to the dearth of information, more observational and longitudinal studies concerning this age group are necessary to confirm some of the main findings.

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Conflict of interest:
Nothing to declare.

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