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ORIGINAL ARTICLE

Relationship between physical activity, physical fitness and multiple metabolic risk in youths from Muzambinho's study

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Abstract
Negative associations between physical activity (PA), physical fitness and multiple metabolic risk factors (MMRF) in youths from populations with low PA are reported. The persistence of this association in moderately-to highly active populations is not, however, well established. The aim of the present study was to investigate this association in a Brazilian city with high frequency of active youths. We assessed 122 subjects (9.9 ± 1.3 years) from Muzambinho city. Body mass index, waist circumference, glycaemia, cholesterolaemia, systolic and diastolic blood pressures were measured. Maximal handgrip strength and one-mile walk/run test were used. Leisure time PA was assessed by interview. Poisson regression was used in the analysis. The model explained 11% of the total variance. Only relative muscular strength and one-mile walk/run were statistically significant ($p < .05$). Those who needed more time to cover the one-mile walk/run test had an increased in metabolic risk of 11%, and those with greater strength reduced the risk by about 82%. In conclusion, children and youths from an active population who need less time to cover the one-mile walk/run test or who had greater muscular strength showed a reduced metabolic risk. These results suggest that even in children and youths with high leisure time PA, a greater aerobic fitness and strength might help to further reduce their MMRF.

Keywords: *Risk factors, childhood, motor activity, aerobic fitness, strength*

Introduction

Metabolic syndrome is a cluster of interrelated metabolic risk factors closely linked to the development of atherosclerotic cardiovascular diseases (Ko et al., 2012; "Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) Final Report", 2002). Similarly to metabolic syndrome in adults, multiple metabolic risk factors clustering (MMRF) has been reported in children and youths since the age of nine years (Pahkala et al., 2012). For example, in youths, the presence of obesity is associated with high blood pressure (Nielsen & Andersen, 2003), glucose intolerance (Sinha et al., 2002) and a profile of dyslipidaemia (Orio et al., 2007). In addition, there is evidence that MMRF track from adolescence into adulthood (Raitakari et al., 2003).

The inverse association between physical activity (PA), physical fitness (PF) and MMRF that is well demonstrated in adults (Carroll & Dudfield, 2004; Yamaoka & Tango, 2012) is not always observed in youths. For example, Andersen et al. (Andersen, Henckel, & Saltin, 1989) found no association between maximal aerobic power and body fat content, blood pressure and blood lipids in a representative sample of Danish schoolchildren. Similarly,

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Sant'Anna et al. (Sant'Anna, Vieira Braga, Moreira, & Sousa, 2011) found no association between PA and MMRF in youths. Other studies showed a negative association between aerobic fitness and MMRF (He et al., 2011; Nielsen & Andersen, 2003; Stabelini Neto et al., 2011) or between PA and MMRF (Brage et al., 2004; Hong, Kim, & Kang, 2009; Kelishadi et al., 2008).

This lack of consistency regarding the inverse association between PA/PF and MMRF in the paediatric population deserves further investigation. The association could vary when different domains of PA or PF markers are considered. In addition, the association may be stronger when MMRF are clustered (Froberg & Andersen, 2005), and also may be different when youths with different levels of PA/PF are considered.

In a previous paper from the Muzambinho's study (Chehuen et al., 2011), we reported that children and youths from this small city in Brazil present a high frequency of MMRF concomitantly with a high frequency of physically active youths. This unexpected coexistence of high PA and MMRF makes it important to investigate the association between MMRF and PF/PA in this active paediatric population. Thus, the objective of this study was to investigate the association between different indicators of PA and PF with the MMRF.

Materials and methods

Sample

The children and youths studied were from Muzambinho, a small city located in the southern state of Minas Gerais in Brazil. At the time of the study, this city had a total population of 20,430 habitants, with 5650 of them aging between 5 and 19 years. As in previous studies (Chehuen et al., 2011; Forjaz et al., 2012), the 10-year-old children who were participating in the Muzambinho's study (Basso et al., 2009), from March 2008 to August 2009 and their siblings formed the sample of this study.

One hundred thirty nine families of the selected children were contacted at their homes for the explanation of the study and signature of the consent forms. The study was approved by the Ethics Committee of the School of Physical Education and Sport, University of São Paulo. Families that agreed to participate in the study received another home visit for collection of blood samples at fasting state. Afterwards, a visit to the child's school was made for other assessments. After all these procedures, the sample consisted of 227 children and youths, accounting for 4.01% of Muzambinho youth population at the time of the study. However, after exclusion due to missing data, the final sample was composed of 122 children and adolescents.

Measurements

Anthropometry and MRF assessment. Body mass and stature were measured with standard equipment (Filizola, Brazil); body mass index (BMI) was calculated by dividing the weight (kilogrammes) by the square root of stature (metres). Waist circumference (WC) was measured with a non-elastic measuring tape positioned at the height of the umbilicus.

Glycaemia and cholesterolaemia were measured by automatic devices (Accu-Check, Advantage II, Roche, Brazil and Accutrend GC, Roche, USA, respectively) with volunteers fasted for at least six hours. These methods have been previously validated against laboratory reference methods (del Cañizo, Froilán, & Moreira-Andrés, 1996; Thomas et al., 2008), and daily optical equipment checks were made according to manufacturer's instructions.

Blood pressure was measured in the non-dominant arm after volunteers had rested seated for five minutes. Measurements were taken by an experienced technician using the auscultatory method and an aneroid sphygmomanometer. Phases I and V of Korotkoff sounds were employed to determine, respectively, systolic (SBP) and diastolic (DBP) blood pressures. Children and youths' arm circumferences were measured and appropriately sized cuffs were chosen. Measurements were taken twice at an interval of 30 seconds, and if a difference greater than 4 mmHg was found, a new measurement was taken. The blood pressure value of each subject was established by the average of the two or three measurements.

Multiple metabolic risk factors. Cutoff values used to identify metabolic risk were as follows: BMI risk of overweight and overweight if $\geq$ 85 percentile (National NCFHS, 2000); WC $\geq$ 95 percentile for age (McCarthy, Jarrett, & Crawley, 2001); glycaemia $\geq$ 100 mg/dl (American Diabetes Association, 2006); total cholesterolaemia $\geq$ 170 mg/dl (Sposito et al., 2007); SBP and/or DBP percentile $\geq$ 90, or if SBP and/or DBP were $\geq$120 and/or 80 mmHg, respectively (Falkner, 2004). After being classified as having or not each metabolic risk factor, the number of MMRF present in each subject was summed.

Physical activity assessment. PA was assessed by a structured interview (Chehuen et al., 2011; Forjaz et al., 2012) conducted by a trained technician with all children and youths assisted by their parents. Briefly, leisure time PA was assessed by asking subjects what they usually did during their free time and school break. For each reported activity, weekly frequency and duration were asked and the weekly volume was calculated by multiplying the frequency by the duration. Children and youths were classified as active when their leisure PA volume was greater than 300 min/week (ACSM, 2010).

Physical fitness assessment. Aerobic fitness was assessed by the one-mile walk/run test (Fitnessgram, 2008) in which a lower time (min) for completing one mile represents better aerobic fitness.

Muscular strength was assessed by a maximal handgrip test and results were normalized by dividing the maximal strength (kg) by the body mass (kg) and expressed as relative strength (kg/kg).

Statistical analysis. Exploratory data analysis was conducted with the statistical package SPSS (version 20.0), and frequencies, means and standard deviation, as well as medians and interquartile ranges, were calculated. Since normality violations were found in most of the variables, Poisson regression analysis was used to examine the associations between MMRF and age, sex, leisure time PA, relative muscle strength and the one-mile walk/run test. STATA 13 was used in these analyses. A level of $p \leq .05$ was accepted as significant.

Results

The sample comprised 65 boys and 57 girls with ages ranging from 6 to 18 years. Their characteristics are presented in Table I.

The frequency of MMRF is shown in Figure 1; the frequency of zeros, (i.e., no risk) is very high (60.7%) relative to other counts and the children and youths with four risk factors constitute 1.6%.

Table II shows the Poisson regression results. The model pseudo-R^2 (explained variance) was 11%. From the five covariates, only two (relative muscular strength and one-mile run) showed significant association with MMRF. Given that the beta coefficients are maximum likelihood estimates and difficult to interpret, their exponentiated values are expressed as prevalence ratios (PR), which makes them easier to understand. Girls, on average, had ~2 risk factors; this is the PR [exponentiation of the intercept (log of the expected count) when all predictors in the model are evaluated at zero]. Children and youths who need more time to cover the one-mile walk/run test have an increase likelihood of metabolic risk of 11%, but those who had greater relative muscular strength reduce the expected number of risk factors by about 82%.

Table I. Descriptive statistic (mean ± standard deviation and median ± interquartile range) of the children and youths of Muzambinho.

	Mean Median	SD IQ
Age (years)	9.90	1.35
	10.08	1.02
Body mass (kg)	33.77	9.25
	31.95	8.20
Stature (m)	137.07	9.72
	137.50	10.50
Risk factors		
BMI (kg/m²)	17.73	3.19
	17.00	3.4
Waist circumference (cm)	63.41	9.27
	62.00	9.0
Glycaemia (mg/dl)	85.01	8.35
	84.00	10
Cholesterolaemia (mg/dl)	158.75	16.32
	153.50	13
Systolic BP (mmHg)	93.66	10.52
	91.00	13
Diastolic BP (mmHg)	59.05	10.17
	60.00	14
Physical activity		
Leisure time PA (min/week)	873.61	729.62
	645.00	933
Physical fitness		
Relative MS	0.51	0.17
	0.50	0.22
One-mile walk/run test time (min)	11.87	2.73
	11.38	4.60

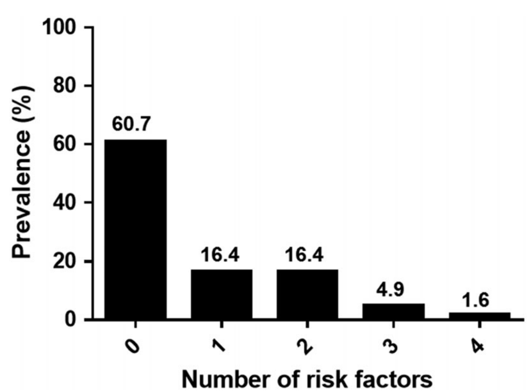

Figure 1. Percentage of Muzambinhos's children and youths by the number of risk factors.

Discussion

The main results of this study were that in Muzambinho's children and youths, there was association between two different domains of PF (aerobic fitness and relative strength) and MMRF, but there was no association between leisure time PA and MMRF.

Although an inverse association between MMRF and PA markers is generally accepted in children

Table II. Poisson regression coefficients, standard errors (SE), *p*-values, prevalence ratio (PR) and corresponding 95% confidence intervals (95% CI).

	Beta (SE)	*p*-value	PR	95% CI
Constant	0.4722 (0.5017)	.347	1.6034	0.5997–4.2869
Age	0.1163 (0.0849)	.171	1.1233	0.9511–1.3267
Sex	0.4690 (0.2422)	.053	1.5984	0.9944–2.5693
Leisure time PA (min/week)	−0.0001 (0.0002)	.334	0.9998	0.9995–1.0000
Relative MS	−1.7161 (0.4671)	<.001	0.1797	0.0719–0.4490
One-mile walk/run test time (s)	0.1033 (0.0423)	.015	1.1088	1.0206–1.2047

and youths (Steele, Brage, Corder, Wareham, & Ekelund, 2008), this association is usually weak and controversial (Froberg & Andersen, 2005). In addition, some reports suggest that this association is stronger or more consistent in individuals with low levels of PA (Andersen et al., 2006; Brage et al., 2004; Hong et al., 2009; Kelishadi et al., 2008; Pahkala et al., 2012; Stabelini Neto et al., 2011; Tanha et al., 2011). Thus, the high level of PA in the Muzambinho's children and youths may explain the absence of association found in the present study.

Interestingly, although MMRF was not associated with PA, it was associated with PF assessed by markers of aerobic fitness and strength. The negative association between aerobic fitness and MMRF in the present study was demonstrated by the fact that children who need more time to finish the one-mile run/walk test, and thus have lower aerobic fitness, have an increased chance of MMRF of ≅11% (as seen by the PR on Table II). Some studies showed similar results, employing different aerobic fitness tests (Dos Santos et al., 2015; Huotari, Nupponen, Laakso, & Kujala, 2010; Photiou et al., 2008), but the present one expands this knowledge by showing the association between MMRF and a very simple test, such as one-mile run test.

Besides aerobic fitness that is usually associated with lower MMRF, the present study also showed that relative muscle strength was negatively associated with MMRF. Concerning this aspect, children and youths who had greater relative muscular strength reduced the expected number of risk factors by about 82%. This finding reinforces the current literature that suggests that strength is associated with lower cardiometabolic risk clustering in boys and girls even after adjustment for cardiorespiratory fitness, level of PA and BMI (Peterson, Saltarelli, Visich, & Gordon, 2014).

Similar to the present results, other studies (Anderssen et al., 2007; Steene-Johannessen, Anderssen, Kolle, & Andersen, 2009) also suggest that association between MMRF and PF are stronger and more consistent than between MMRF and PA. The clinical application of the present results are that, at least in children and youths with high levels of PA, an increase in PF by increasing aerobic fitness and/or relative muscle strength might be desirable for reducing MMRF.

Notwithstanding the importance of the present findings, this study has some limitations. Because of its cross-sectional design, a cause and effect association cannot be stated. The sample comprised children and youths from an active population of a small city and the results may not be applicable to populations with different characteristics. Note that our sample was reduced by technical problems during our analytical work (i.e., blood collection). Yet, an a posteriori sample size estimation was conducted with G*Power 3.1.5 (Faul, Erdfelder, Buchner, & Lang, 2009) with the following conditions: alfa level = 0.05, power = 0.80, exp(B0), baseline response rate = 0.50, rate ratio (exp(b0)/exp(B1)) = 1.1, mean exposure time = 1, Phi = 1, R-square of X1 with other X's = 0.10, distribution of X1 = Normal, and the result was 149 subjects. Although we are slightly underpowered, the observation of significant results with fewer cases reinforces the importance of the findings. Due to ethical reasons, we were not able to collect information regarding biological maturation, and this limits the explanation of our results. The study used a structured interview, which was previously use in other studies (Chehuen et al., 2011; Forjaz et al., 2012) to assess PA and results might probably be different if accelerometers would be used.

In conclusion, in children and youths from an active population, those who need more time to cover the one-mile run/walk test have an increased chance of metabolic risk, while those who have greater relative muscular strength reduce the expected number of risk factors. These results suggest that even in children and youths with high leisure time PA, a greater aerobic fitness and strength might help to further reduce MMRF.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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