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Physical activity, BMI and metabolic risk in Portuguese adolescents

Atividade física, IMC e risco metabólico em adolescentes portugueses

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Abstract – It has been reported, in the last decades, a significant decrease in physical activity (PA) levels, with a consequent increase in obesity and metabolic risk factors among youth. The aims of this study were to describe PA levels, the prevalence of overweight/obesity and metabolic risk factors, and to examine the association between PA and body mass index (BMI) with metabolic risk among Portuguese youth. The sample comprises 212 Portuguese adolescents (12-16 years old). Height and weight were measured. PA was estimated with the Bouchard questionnaire (3 days recall), as well as with the use of a pedometer (used for 5 consecutive days). Metabolic risk factors comprised fasting glucose, triglycerides, HDL-cholesterol, systolic blood pressure and waist circumference. Subjects were classified as normal weight, overweight or obese according to BMI; the maturational status was indirectly estimated with the maturity offset procedure. A continuous metabolic risk score was computed (zMR) and PA values were divided into tertiles. Qui-square test, t-test and ANOVA were used in statistical analyses. SPSS 18.0 and WinPepi softwares were used and $p<0.05$. A moderate to high prevalence of overweight/obesity and HDL-cholesterol was found, as well as a high prevalence of high blood pressure and low to moderate PA levels among Portuguese youth. The relationship between BMI and zMR showed that obese adolescents have higher zMR when compared to normal weight or overweight adolescents. This finding suggests that increased levels of PA and reduction in the prevalence of overweight/obesity may have a positive role against the development of metabolic risk factors.

Key words: Physical activity; BMI; Metabolic risk.

Resumo – *Tem-se verificado, nas últimas décadas, uma redução substancial nos níveis de atividade física (AF), com o consequente aumento da prevalência de sobrepeso/obesidade e fatores de risco metabólico entre jovens. O presente estudo teve por objetivos identificar os níveis de AF e as prevalências de sobrepeso/obesidade e risco metabólico, e associar o índice ponderal com os níveis de AF e risco metabólico em jovens portugueses. A amostra foi composta por 212 jovens portugueses (12-16 anos). Estatura e peso foram mensurados. AF foi estimada a partir do recordatório de 3 dias de Bouchard e pelo uso do pedômetro (durante 5 dias). Os indicadores de risco metabólico considerados foram: glicose, triglicerídeos, HDL-colesterol, tensão arterial sistólica e perímetro da cintura. Os sujeitos foram classificados consoante índice ponderal a partir do índice de massa corporal, enquanto que o estatuto maturacional foi estimado a partir do offset maturacional. Score contínuo de risco metabólico (zRM) foi calculado, e a AF foi dividida em tercis. Os testes estatísticos utilizados foram o Qui-quadrado, teste t independente e ANOVA, as análises foram conduzidas no SPSS 18.0 e WinPepi ($p<0,05$). Observou-se uma prevalência moderada a elevada de sobrepeso/obesidade e HDL-colesterol, uma elevada prevalência de risco para tensão arterial, e níveis de AF baixos a moderados entre jovens portugueses. A relação entre índice ponderal e zRM mostrou que adolescentes obesos apresentam maior zRM comparativamente aos adolescentes normoponderais ou com sobrepeso. Incrementos nos níveis de AF e redução da prevalência de sobrepeso/obesidade podem ter um papel relevante na redução de fatores de risco metabólico.*

Palavras-chave: *Atividade física; IMC; Risco metabólico.*

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INTRODUCTION

The worldwide increase in the prevalence of overweight/obesity in paediatric population, in association with the increase in the incidence of cardiometabolic disease (CMD), suggests that obesity has probably been the most common chronic disease in childhood[1,2]. Further, an increase in sedentariness among youth has also been observed, with implications in the prevalence of non-communicable diseases and also in the general health of the world population[3].

It has been estimated that in 2020 about 60 million preschool children worldwide will be overweight/obese[1], and it has been expected that this scenario reaches the young population. Janssen et al[4] reviewing data from 34 countries (Europe, USA and Israel) reported that the prevalence of overweight/obesity in school-children ranged from 5.5% (Lithuania) to 33.3% (Malta). Since that obese youth are more likely to become obese adults[2] and that this pandemic leads to increasing risk to the development of CMD, these data are of great concern, especially with regards to economic costs reaching about €169 billion/year in Europe Union[5].

Regarding to sedentary behaviour in the paediatric population, available information are of similar concern. About 80.3% of adolescents worldwide do not reach the daily recommended physical activity (PA) guidelines (60 minutes of moderate-to-vigorous PA); further, sex differences are observed, where boys tend to be more active[6].

Since there is a relationship between obesity, sedentariness and development of CMD, it is expected that the prevalence of metabolic risk (MR) has also increased in youth. In a review (with studies conducted in USA and Australia), Huang et al[7] reported that the metabolic syndrome in the paediatric population ranges between 0% and 60%; however, these prevalences vary according to studied sample as well as to the metabolic syndrome cut-points used.

Data from the Portuguese population, aged 10-18 years, show a similar trend to that observed in different countries: prevalence of overweight/obesity ranges between 21.6% and 32.7% in girls, and between 23.5% and 30.7% in boys, varying according to the cut-point used[8]. Regarding to PA levels, 36% of children aged 10-11 years (boys: 51.6%; girls: 22.5%) and 4% of adolescents aged 16-17 years (boys: 7.9%; girls: 1.2%) comply with the guidelines[9]. In addition, Portuguese adolescents spend about 545 minutes in sedentary activities (SedAct), with girls spending more time in these activities[10]. As regards to MR factors, available data show that in the paediatric population its prevalence ranges from 7.2% to 34.9%, varying according to sample characteristics and cut-points used[11,12].

Given the scenario described so far, the purposes of this study are twofold: (1) to describe PA levels, and the prevalence of overweight/obesity and MR factors, and (2) to examine the association between PA and body mass index (BMI) with MR among Portuguese youth from both sexes.

METHODOLOGICAL PROCEDURES

Sample

The sample comprises 212 adolescents (116 boys, 96 girls), aged 12-16 years, from three schools from Oporto metropolitan area, Portugal. This is a convenience sample. Inclusion criterion was that children had to have siblings studying at the same school. After the identification of eligible children, a consent form was sent to parents/legal guardians. Adolescents with special education needs, physical handicaps or psychological disorders that might impair their daily routines, namely their PA's (structured or non-structured), were excluded. G*Power v.3.1.5[13] software was used to estimate the sample size, taking into account the following conditions to the regression model, from which the t-test and ANOVA can be considered as particular cases: number of predictors=5, alfa=5%, power=95%, Cohen f^2=0.10; the suggested sample size was of 132 subjects. The increase in sample size from that suggested by the software was due to the interest in obtaining information from all the subjects with a signed consent form, ~70%. The project was approved by the University of Porto ethics committee.

Anthropometry

Height and weight were obtained according to procedures described by Lohman et al.[14], with youth wearing light clothes and with no shoes. Height was measured with a portable Harpenden (±0.1cm). Weight was measured by a Tanita® bioimpedance scale, model BC-418 MA (±0.1kg). Waist circumference was measured at the smallest circumference between the lowest rib and the superior iliac crest, to the nearest 0.1cm, using a Sanny non-elastic tape. The BMI was computed using the standard formula [weight(kg)/height(m)^2], and subjects were classified as normal-weight, overweight or obese[15].

Physical Activity

Physical activity was estimated with a multimodal approach using the Bouchard 3-days recall questionnaire[16] and the *New Lifestyles NL-1000* pedometer.

The Bouchard 3-days recall questionnaire allows to estimate time spend in SedAct (including sleep time), light PA (LPA) and vigorous PA (VPA), and also gives an estimation of energy expenditure (two weekdays and one weekend day). Briefly, the day is divided in 96 periods of 15 minutes each from which subjects have to describe the dominant activity performed in each of these periods; each activity is categorized in a scale from 1 to 9 (in an increasing level) with the purpose to estimate the energy expenditure of each activity in each period. The mean energy expenditure in each of 9 categories (expressed in kcal/kg/15min) was used to determine the subject total energy expenditure. The questionnaire was applied by direct interview. Subjects reported activities performed in three days of the week from the last week, from the awake to bedtime; each 15 minutes of activity was encoded by the interviewer according to the questionnaire protocol.

The pedometer gives information regarding to the total number of steps given in each monitored day. Subjects wore the pedometer during 5 days, from Thursday to Monday (also in agreement with the information from the 3-days recall questionnaire). They were given the instruction to remove the device only when performing activities involving water or when going to sleep.

Metabolic Risk

The MR indicators considered were: HDL-cholesterol (HDL-C), glucose (GLU), triglycerides (TRIG), waist circumference (WC) and systolic blood pressure (SBP). Information of fasting GLU, HDL-C and TRIG were obtained from finger-stick blood samples of 35µl, analysed with a Cholestech® LDX point-of-care analyser. Subjects were instructed to be in fasting conditions for at least 10-12 hours.

Resting SBP was measured according to procedures described by the *National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents*[17]. Digital Omron® (M10-IT) sphygmomanometers were used; three measurements were taken, on the right arm, with a three minutes interval, and the mean value of the three blood pressure measurements was used. Before the first measurement, subjects should be at rest for at least 10 minutes.

Cut-points suggested by Cook et al[18] were used to determine MR in all subjects.

Biological Maturation

The maturity offset procedure[19] was used as a method to estimate biological maturity. The maturity offset allows estimating the distance, in decimal years, each subject is from peak height velocity (PHV) age.

Statistical Analysis

Descriptive information (mean±standard deviation and prevalences) was split by sex. Differences in the frequencies of risk indicators were done by a chi-square test. A standardized MR score (zMR) was computed by summing the metabolic indicators transformed in z-scores (HDL-C z-score was previously multiplied by -1). The lower the zMR is, the better the MR. The distribution of PA values derived from the Bouchard 3-days recall (kcal/kg) was divided in tertiles, as suggested by Pan et al[20], such that those in the first tertile are the less active subjects, and those in the last tertile are the more active.

Adjusted adolescents' zMR for biological maturation were computed using a multiple regression analysis. The t-test was used to compute differences between sexes in all variables. Analysis of variance (ANOVA) was used to test for differences in zMR among PA tertiles and BMI categories. All statistics were done in SPSS 18.0 and WinPepi; the significance level was set at 5%.

RESULTS

Table 1 shows results of descriptive statistics and t-test results for anthropometric variables and MR indicators. On average, boys are significantly ($p<0.05$) taller, have higher SBP, GLU, and WC, but have lower TRIG and HDL-C.

Table 1. Mean and standard deviation (M±sd) values for anthropometric variables and MR indicators by sex.

	Boys (M±sd)	Girls (M±sd)	*p-value*
Age (years)	14.11±1.26	14.16±1.41	0.817
Height cm)	162.86±10.17	158.66±5.96	<0.001
Weight (Kg)	58.12±14.12	56.30±9.75	0.268
BMI ($kg.m^2$)	21.73±4.03	22.33±3.50	0.245
SBP (mmHg)	120.57±12.67	115.27±8.94	0.001
HDL-C ($mg{\cdot}dL^{-1}$)	46.80±13.71	52.74±13.24	0.002
TRIG ($mg{\cdot}dL^{-1}$)	59.14±22.64	76.47±38.39	<0.001
GLU ($mg{\cdot}dL^{-1}$)	86.62±7.46	83.77±7.42	0.006
WC(cm)	73.63±9.79	70.21±8.77	0.009

BMI=Body Mass Index; SBP=Systolic Blood Pressure; HDL-C=High-Density Lipoprotein Cholesterol; TRIG=Triglycerides; GLU=Glucose; WC=Waist Circumference.

About 60% of boys and 62% of girls are normal weight, and about 41% of boys and 39% of girls are overweight/obese. However, these frequencies are not different between the sexes ($p>0.05$).

The risk prevalences for each metabolic indicator are in table 2. The SBP is the indicator with the higher risk prevalence, followed by HDL-C and TRIG. On the other hand, a lower prevalence was observed for WC and no risk was found for GLU. Statistically significant differences were observed between boys and girls in HDL-C and TRIG frequencies, where boys had higher prevalence for HDL-C ($p=0.043$), while girls showed higher values for TRIG ($p=0.042$).

Table 2. Risk prevalence for each metabolic indicator by sex.

Prevalence (%) – Risk Indicators					
	Boys		Girls		p-value
	Without Risk	At Risk	Without Risk	At Risk	
SBP (mmHg)	22.4	77.6	20.8	79.2	0.781
HDL-C ($mg{\cdot}dL^{-1}$)	71.6	28.4	83.3	16.7	0.043
TRIG ($mg{\cdot}dL^{-1}$)	93.1	6.9	84.4	15.6	0.042
GLU ($mg{\cdot}dL^{-1}$)	100.0	-----	100.0	------	-----
WC (cm)	94.8	5.2	93.8	6.3	0.735

SBP=Systolic Blood Pressure; HDL-C=High-Density Lipoprotein Cholesterol; TRIG=Triglycerides; GLU=Glucose; WC=Waist Circumference.

On average, adolescents spend most of their time in SedAct (table 3). Girls spend less than one hour/day in VPA, while boys spend, ap-

proximately, 84 minutes (p<0.001). Similarly, boys have a higher energy expenditure, in about 2 kcal·kg^{-1} (p=0.003), in agreement with their higher involvement in VPA.

Pedometer results are in accordance with results reported above. Boys have, on average, higher number of steps during week-days (p=0.024).

Table 3. Mean and standard deviation (M±sd) values for time spent in SedAct, LPA, and VPA, and number of steps, by sex.

	Physical Activity		
	Boys (M±sd)	Girls (M±sd)	p-value
	Time Spent		
Sedentary (min·d^{-1})	1251.85±103.61	1250.42±89.04	0.914
Low Physical Activity (min·d^{-1})	103.49±75.53	145.63±76.67	<0.001
Vigorous Physical Activity (min·d^{-1})	84.66±75.86	43.91±53.59	<0.001
	Energy Expenditure (Kcal·Kg^{-1})		
	39.55±5.80	37.42±4.02	0.003
	Number of Steps		
Week-days	10313±3334	8797±2808	0.024
Weekend	6068±4462	5140±2708	0.253

The ANOVA results for BMI and zMR, not adjusted for biological maturation, showed statistically significant differences between normal weight and overweight girls, and between normal weight and obese girls (p<0.001); in boys, statistically significant differences were observed among the three BMI groups (p<0.001). For the relationship between BMI and zMR adjusted for biological maturation, statistically significant differences were observed among the three categories only for girls (p<0.001). In general, results show that obese boys and girls have higher MR than their normal weight peers (p<0.001) (table 4).

Table 4. Mean and standard deviation (M±sd) values among BMI groups, by sex.

		Normal weight	Overweight	Obese	
		M±sd	M±sd	M±sd	p-value
zMR (not-adjusted)	Boys*	-0.79±0.31	1.56±0.44	4.78±0.71	<0.001
	Girls**	-1.35±0.28	0.36±0.40	1.68±0.90	<0.001
zMR (adjusted for maturation)	Boys	0.09±0.14	0.24±0.20	0.87±0.32	0.092
	Girls*	-0.61±0.14	0.12±0.59	1.46±0.36	<0.001

zMR=metabolic risk continuous score *Normal weight<Overweight<Obese; **Normal weight<Overweight; Normal weight<Obese.

The ANOVA results for PA and zMR (table 5) did not show statistically significant differences in mean values of zMR among PA tertiles for both sexes. However, when zMR was adjusted for biological maturation, a marginal value (p=0.068) was observed for the mean difference between the 1st and 2nd tertiles of PA in boys.

Table 5. Mean values and standard deviation (M±sd) among PA tertiles and p values for MR continuous score, by sex.

		1st Tertile	2nd Tertile	3rd Tertile	
		M±sd	M±sd	M±sd	p-value
zMR (not adjusted)	Boys	0.84±0.51	0.42±0.49	0.31±0.51	0.733
	Girls	-0.11±0.42	-0.51±0.42	-1.22±0.42	0.178
zMR (adjusted for maturation)	Boys*	0.48±0.19	-0.11±0.18	0.33±0.19	0.068
	Girls	-0.20±0.18	-0.05±0.18	-0.48±0.18	0.242

zRM=metabolic risk continuous score. *1st Tertile>2nd Tertile

DISCUSSION

The worldwide increase in the prevalence of overweight/obesity in youth, and the reduction of their PA levels, has consistently been associated with the increase in the prevalence of MR factors in the paediatric population. Aiming to better understand this "scenario" in Portuguese youth, the present study identified their PA levels, prevalence of overweight/obesity and MR, as well as their associations.

On average, we found significant differences between sexes in metabolic indicators, where boys have higher SBP, GLU, and WC values, but lower TRIG and HDL-C. Although sex-differences have been frequently reported in previous studies, results are divergent. For example, Haas et al.[21] data, with German youth, presented similar results to those from the present study about SBP, GLU, WC, and TRIG sex-differences; however, they also reported a different result in HDL-C means (boys with higher values). On the other hand, Bozza et al.[22] did not report statistically significant differences for HDL-C and TRIG, but only higher SBP and WC in boys.

Overweight/obesity prevalence in Portuguese youth is high (boys: 41%; girls: 39%). Moderate-to-high prevalence of overweight/obesity in paediatric population from different countries have also been reported[1,4]. For example, in a review involving Brazilian youth, Tassitano et al.[23] reported prevalences reaching 28.2% among adolescents. Similarly, Janssen et al.[4] described overweight/obesity prevalences higher than 15% in Canadian, American, English, Scottish, Gaulish, Greek, Italian, Maltese, Spanish, and Portuguese youth. On the other hand, in this same study, a low prevalence of overweight/obesity (lower than 10%) was found in Czech Republic, Estonia, Latvia, Lithuania, Poland, Russia and Ukraine youth. Even smaller prevalences of overweight/obesity have been observed in Africa. For example, dos Santos et al.[24], studying Mozambican youth, identified a overweight/obesity prevalence lower than 1%. These results show that, regardless of the increases in the prevalence of overweight/obesity in the paediatric population, this epidemiological problem does not affect all nations in the same proportion. It has been suggested that changes in behavioural (a more sedentary lifestyle) and nutritional habits (consumption of high energy-dense foods) are probably one of the major agents behind these increases[1]. Using data from a 2008 report by Sardinha

et al.[8] about overweight/obese prevalences in mainland, Portugal, namely data from the North region, allowed us to conclude that the present study data is far different (boys: 40.5% vs 25.1%; girls: 38.5% vs 21.8%). This most probably reflect changes in youth habits which may lead to increases in the excess weight prevalence, or can be related to the specifics of the sample. It is important to note, however, that the rise in overweight/obese prevalences observed in Portuguese youth parallels the worldwide trend, especially among European countries[4].

Along with the high prevalence of youth with excess weight, a high and moderate prevalence of adolescents at risk for SBP (boys: 77.6%; girls: 79.2%) and HDL-C was observed, respectively. In Portugal, hypertension has been pointed as the major risk factor for cardiovascular disease, reaching about 42% of the adult population[25]. This prevalence in Portuguese adult population is similar to that observed in paediatric population, since a moderate prevalence of hypertension and pre-hypertension among Portuguese youth was previous reported, with values of 34% (boys: 44%; girls: 21%) and 12% (boys: 10%; girls: 13%), respectively[26]. Although the prevalence of Portuguese youth at risk for SBP was higher than that observed in other samples[27], results are in accordance with the high hypertension prevalence observed among Portuguese adult population. However, it is possible that differences in methods and sample size, as well as different protocols used to estimate the SBP can be related to these differences. The moderate prevalence of adolescents at risk for HDL-C (boys: 28.4%; girls: 16.7%) is also of concern, although similar results were previous reported among Brazilian youth (boys: 39%; girls: 27%)[28].

Overweight/obesity increases in youth is usually associated with increases in sedentary behaviours as well as decreases in their moderate-to-high PA levels. In the present study, results from the recall questionnaire showed that girls had lower PA levels, spend little time in VPA, while boys were more active and more frequently reached the recommended levels. Girls data are in agreement with that reported in a recent review[6], where 80.3% of youth worldwide, aged 13-15 years, do not reach the daily recommended guidelines for moderate-to-vigorous PA; similarly, girls showed higher sedentariness frequencies when compared to boys. Pedometer results further confirmed that adolescents do not reach the recommended number of daily steps (boys: 15000; girls: 12000)[29]. These data are consistent with the recall questionnaire only in girls.

The relationship between MR and BMI showed, in general, that overweight/obese adolescents have higher MR, reinforcing that higher BMI increases the risk for the development of CMD and/or risk factors related to them[2]. The protective effect of moderate-to-vigorous PA levels in the reduction of cardiovascular risk factors has been currently reported[30]. However, in the present study, except for the inverse relationship observed between PA and MR adjusted for maturational status in boys, no other statistically significant relationship was found; but, the identified trend that more active subjects have lower MR is similar to previous research,

reinforcing the role of PA in the reduction of CMD development. Similarly to the results of the present study, Stabelini Neto et al.[28], investigating Brazilian youth, and Pan & Pratt[20], studying North-American youth, did not find statistically significant association between PA and MR, but reported a trend to a lower prevalence of MR among more active subjects.

Notwithstanding the relevance of the present data, there are, at least, two limitations: (1) the use of a recall questionnaire to estimate PA levels, although the concurrent use of the pedometer may limit its problems; and (2) the small sample size, though similar studies have sample sizes within the range of the present one[30]. Even with these limitations, this data is of importance for public health professionals.

CONCLUSION

The present study investigated the relationships between PA, BMI and MR indicators in Portuguese youth. In general, girls have low-to-moderate PA levels, while boys have moderate levels; a significant part of the awake time is spent in SedAct. A moderate-to-high prevalence for overweight/obesity as well as for HDL-C was observed; however, the highest observed risk was for SBP. Obese adolescents have higher zMR compared with those classified as normal weight or overweight. These results confirm that prevention strategies must be implemented, aiming to increase PA levels in youth, as well as monitoring/controlling MR factors, especially in obese, aiming to reduce its frequency and consequences in adult life.

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