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PEDIATRIC ORIGINAL ARTICLE

Body mass index, cardiorespiratory fitness and cardiometabolic risk factors in youth from Portugal and Mozambique

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OBJECTIVES: The objectives of this study are to examine differences in cardiometabolic risk indicators, as well as their prevalences, in Portuguese and Mozambican youth, and to investigate the associations between weight status and cardiorespiratory fitness levels with cardiometabolic risk.
METHODS: The sample comprises 721 adolescents (323 Mozambican and 398 Portuguese), aged 10–15 years. Anthropometry (height, sitting height, weight and waist circumference), blood pressure, serum-fasting triglycerides, high-density lipoprotein cholesterol and glucose, and cardiorespiratory fitness were measured. Maturity offset was estimated and a cardiometabolic risk score adjusted for sex, age and biological maturity was computed. Adolescents were classified as normal weight and overweight/obese as well as fit or unfit (cardiorespiratory fitness).
RESULTS: Portuguese youth have better cardiometabolic and cardiorespiratory fitness profiles. About 32% and 30% of Portuguese boys and girls, respectively, are overweight/obese; in Mozambicans, these prevalences are 7.5% for boys and 21% for girls; in addition, 81.6% of Portuguese boys and 77.7% of Portuguese girls were classified as cardiorespiratory fit, against 54% and 44.4% of Mozambican boys and girls, respectively. No statistically significant differences ($P > 0.05$) were found between Mozambicans and Portuguese for the cluster of three or more cardiometabolic risk indicators. A positive relationship ($P < 0.001$) was found between weight status and cardiometabolic risk in adolescents from both countries; however, a negative association ($P < 0.001$) between cardiorespiratory fitness and cardiometabolic risk was only found among Portuguese youth.
CONCLUSIONS: Portuguese and Mozambican youth differ in their cardiometabolic risk profiles, body weight and cardiorespiratory fitness, favoring Portuguese. Overweight/obesity and low cardiorespiratory fitness levels are related to a worse cardiometabolic risk profile, being relevant to design public health intervention strategies to reduce excess weight and increase cardiorespiratory fitness.

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INTRODUCTION

Childhood obesity is a major public health problem across the world.[1,2] In addition, it is closely linked with several non-communicable diseases and with the metabolic syndrome,[3] which is defined as a cluster of three or more metabolic abnormalities, like abdominal obesity, high blood pressure, dyslipidemia and dysglycemia.[4] There is consistent evidence that this cluster of metabolic indicators is prevalent in youth;[5] further, its presence parallels the worldwide prevalence of childhood obesity. For example, among North American, Asian and European youth,[6] the prevalence of metabolic syndrome in normal weight children and adolescents is 1% or less, whereas in obese youth it ranges from 18 to 50%; among Chinese adolescents,[7] a prevalence of 3.7% was found in the overall sample but the prevalences were 35.2%, 23.4% and 2.3% among obese, overweight and normal weight groups, respectively. Moreover, a recent review of metabolic syndrome prevalence in children from North America, Latin America, Europe, Asia and Australasia[5] showed overall prevalences ranging from 1.2 to 22.6%, but when considering only overweight/obese children this value was up to 60%.

It is widely acknowledged that the prevalence of childhood overweight/obesity has increased not only in industrialized but also in least developed and developing countries.[8] However, there is some suggestion of a plateau in the increase in prevalence in some industrialized countries.[9,10] On the other hand, in developing nations, the scenario of a systematic overweight/obesity increase is a reality, as a consequence of the transition process associated with the adoption of Western lifestyles, characterized by high consumption of energy-dense foods, low levels of physical activity and increases in sedentary time. For example, in Brazil, the childhood obesity prevalence increased from 4.1 to 13.9% from 1974–1997; in Thailand, the observed increase was from 12.2 to 15.6% between 1991 and 1993; and in India, the prevalence increased from 9.8 to 11.7% between 2006–2009.[11]

There is some evidence that cardiorespiratory fitness levels are inversely correlated with metabolic risk in European and North-American youth,[12] suggesting that high physical fitness attenuates the effects of fatness on metabolic risk indicators.[13] A decline of physical activity in children and adolescents in developing countries has also been reported,[14,15] which could have negatively impacted their physical fitness levels.[14,16] It is possible that these changes, in association with increases in overweight and obesity, may have a negative impact on overall population health.

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It is widely acknowledged that socioeconomic characteristics have distinct impacts on children's health, especially in the prevalence of overweight/obesity and its co-morbidities.[1,17] In general, children from industrialized, developing and least developed countries differ in their health status because of lifestyle differences in response to social, economic and cultural differences.[18] Investigating health markers in children from different countries, that is, from distinct socioeconomic contexts, may provide a better understanding about the impact of socioeconomic gradients in their health. Examining the relationship of metabolic risk indicators with weight status and cardiorespiratory fitness in youth living in distinct environments may help the development of more efficient public health strategies to decrease the incidence of health hazards during this life period as well as in adulthood. As such, this study aimed to: (i) examine differences in cardiometabolic risk indicators, as well as their prevalences in Portuguese and Mozambican youth; (ii) investigate the associations between weight status and cardiorespiratory fitness levels with cardiometabolic risk in these youth.

MATERIALS AND METHODS

Sample

The sample of this study comprises school children and adolescents, aged 10–15 years, from Mozambique (capital city, Maputo) and Portugal (Oporto metropolitan area). The Mozambican sample is part of the *Human Biological Variability – Implications for Physical Education, Sports, Preventive Medicine and Public Health* research project, which aims to describe the patterns of human variability in growth, biological maturation and development of Mozambican youth, and is comprised only of urban/suburban youth.[19] The Portuguese sample is part of *The Oporto Growth, Health and Performance Study*, which investigates the relationship among growth, body composition, physical activity, physical fitness, nutritional and health behaviors in Portuguese youth.

The data collection was carried out during the 2012 and 2013 school years in Mozambique and in 2011–2013 in Portugal. The total sample comprises 721 subjects, distributed as follows: 323 Mozambicans (161 boys and 162 girls) and 398 Portuguese (174 boys and 224 girls). Children with chronic diseases, physical handicaps or psychological disorders that might impair their daily routines, physical activities or motor testing, those younger than 10 or older than 15 years, were excluded during sample selection and/or data screening. All children involved in the study had a written consent signed by parents or legal guardians.

The Mozambican National Bioethics Committee (Mozambique) and the University of Porto Ethics Committee (Portugal), as well as respective school authorities, approved the study.

Mozambique and Portugal socio-demographic characteristics

Mozambique is located in Southern Africa, bordered by the Indian Ocean, Tanzania, Malawi, Zambia, Zimbabwe, Swaziland and South Africa; and Portugal is located in Southwest Europe, bordered by the Atlantic Ocean and Spain.

Mozambique has a population estimated at 25 million, with an annual growth rate of 2.4%, and with about 31.4% of the population living in urban settings.[20] The Portuguese population is ~10.6 million, and about 61.6% of the population lives in urban areas.[21]

Mozambican life expectancy is 53 years, with a child mortality rate of 84 deaths per 1000 births and a literacy rate of 50.6%.[20,22] Portugal has a life expectancy of 79.7 years, a child mortality rate of 4 deaths per 1000 births, and a literacy rate of 95.4%.[23,24] Further, the Mozambique has a gross national income/per capita estimated in \$510[ref. 20] and has a human development index (2012) of 0.327, which classifies it as a least developed country.[23] Portugal has a gross national income/per capita of \$20 580 and a human development index of 0.816, which classifies it as an industrialized country.[23,24]

Anthropometry

Height, sitting height and weight were measured according to procedures described by Lohman *et al.*[25] In Portugal, children were measured wearing light clothes, without shoes or socks, whereas in Mozambique children were assessed without shoes and naked in two private rooms, one for each sex (girls were measured by female technicians and boys were measured by male technicians). Height and sitting height were measured to the nearest 0.1 cm with the head positioned in the Frankfurt plane with a portable stadiometer (Holtain Ltd, Dyfeld, UK); weight was measured using a calibrated portable Seca (Seca, Hamburg, Germany) scale (in Mozambique) and a portable bioelectrical impedance (TANITA BC-418 MA Segmental Body Composition Analyser; Tanita, Corporation, Tokyo, Japan) scale (in Portugal), with a precision of 0.1 kg.

Body mass index (BMI) was computed using the standard formula [weight(kg)/height(m)^2], and subjects were classified in two groups (normal weight and overweight/obese) according to the International Obesity Task Force cut points.[26]

Cardiorespiratory fitness

Cardiorespiratory fitness was estimated by the 1-mile run/walk test from the Fitnessgram battery.[27] Time to cover the distance (minutes and seconds) was used to classify children as fit or unfit according to age- and sex-specific Fitnessgram cut points.

Biological maturation

An estimate of biological maturity was obtained using the maturity offset method.[28] This method estimates the distance, in decimal years, each subject is from the peak height velocity (PHV), using information on sex, age and individual growth (sitting height, height and body weight). The value is expressed in years from PHV either + or −, where a positive maturity offset indicates the number of years a child is beyond PHV, whereas a negative maturity offset indicates the number of years before PHV.

Cardiometabolic risk

Cardiometabolic risk indicators included waist circumference, mean arterial blood pressure (MAP), fasting glucose, triglycerides and high-density lipoprotein cholesterol (HDL-C). Waist circumference was measured using a non-elastic tape (Sanny, American Medical of Brazil, São Paulo, Brazil) at the smallest circumference between the lowest rib and the superior iliac crest, to the nearest 0.1 cm, with subjects standing erect with relaxed abdominal muscles at the end of normal expiration. Resting systolic (SBP) and diastolic blood pressure (DBP) were measured using a digital Omron sphygmomanometer (models M4-I (HEM-752A-E) and M6 (HEM-7001-E), Omron Healthcare (Hoofddorp, Netherlands), in Mozambique and Portugal, respectively), after children and adolescents had been at rest for at least 5 min. Three measurements were taken, with a 3-min interval, and the mean of the three blood pressure measurements was used for further analysis. All individuals remained seated with back relaxed and against the chair, legs uncrossed and the feet flat on the floor, and the arm where measurements were taken was positioned with a support at the heart level, palm turned upwards and the elbow slightly flexed. The MAP was computed as: [(SBP-DBP)/3+DBP]. Finger-stick blood samples were collected after an overnight fast of at least 10–12 h, and glucose, triglycerides and HDL-C were analyzed with a Cholestech LDX point-of-care analyser, in Portugal, and a CardioCheck PA analyser, in Mozambique. These methods have been previously validated against laboratory reference methods,[29] and daily optical equipment checks were made according to the manufacturer's instructions. The blood collection was performed at school, by a trained technician, in a private room, and blood analysis was done immediately at the same place of blood collection. This procedure (blood collection and blood analysis) took about 5–10 min and was performed in the morning.

A standardized cardiometabolic risk (zCR) score was computed using MAP, waist circumference, glucose, triglycerides and HDL-C as previous described.[30] All cardiometabolic risk indicators' values were adjusted for sex, age and biological maturity using a stepwise regression analysis, and their standardized residuals obtained. The zCR was derived by summing the continuously distributed cardiometabolic risk indicators, with the HDL-C z-score been previously multiplied by −1 (given its negative relationship with cardiometabolic risk). A lower zCR is indicative of a better cardiometabolic profile. Further, cutoff points suggested by Cook *et al.*[31] were also used in a follow-up analysis to define the presence of risk in each cardiometabolic risk indicator.

Statistical analysis

Mean differences by country and sex in each of the individual cardiometabolic risk indicators, zCR and cardiorespiratory fitness were analyzed with the *t*-test (raw data) and with analysis of covariance, controlling for sex, age and biological maturity; analysis of covariance was also used to analyze differences in biological maturity, controlling for sex. Differences in the frequencies of subjects at elevated risk for each cardiometabolic risk indicator, as well as in the frequencies of subjects distributed according to BMI and cardiorespiratory fitness groups between countries were verified by a χ^2 test. All analyses were done in SPSS 20 and WINPEPI,[32] and the significance level was set at 5%.

RESULTS

Descriptive statistics are presented in Table 1. Except for triglycerides, SBP and waist circumference (in girls), significant differences ($P < 0.05$) were observed between countries. Portuguese youth have a better zCR, a lower DBP and a higher HDL-C, whereas Mozambican youth have a lower waist circumference (boys) and glucose. Further, Portuguese children and adolescents spend less time to cover the 1-mile distance and are closer to their PHV than their peers from Maputo.

Figure 1 shows the analysis of covariance results for differences, by sex and country, for each cardiometabolic risk indicator, zCR, BMI and cardiorespiratory fitness, adjusted for age and biological maturation. Except for BMI, triglycerides and glucose (in boys), significant differences ($P < 0.05$) were observed between countries, with Portuguese youth having a better cardiometabolic profile: lower mean values for waist circumference, SBP, DBP, MAP and zCR, and a higher value in HDL-C. The results for cardiorespiratory fitness were similar to that found without age- and maturation-adjustment. In addition, glucose, among girls, was the only indicator where Mozambicans showed a better profile.

Table 2 summarizes frequencies for each cardiometabolic risk indicator, as well as the frequency of children classified according to weight status and cardiorespiratory fitness levels, by country and sex. About 32% of Portuguese boys and 30% of Portuguese girls were classified as overweight/obese, whereas in Maputo, these frequencies were 7.5% and 21%, respectively ($P < 0.05$). Regarding cardiorespiratory fitness, a higher percentage of Portuguese youth was classified as fit ($P < 0.001$), in both sexes, when compared with those from Maputo (81.6% of Portuguese boys and 77.7% of Portuguese girls, against 54% of Mozambican boys and 44.4% of Mozambican girls). A higher percentage of Portuguese boys are at risk for waist circumference ($P = 0.010$) and triglycerides ($P = 0.011$), whereas Mozambican boys and girls showed a high-risk frequency for blood pressure (at risk for SBP and/or DBP; $P < 0.05$) and HDL ($P < 0.001$), which is the indicator with the highest prevalence in boys for both countries and in Mozambican girls. About 22% of Mozambican boys and girls did not present any risk factor, whereas in the Portuguese sample these percentages were, respectively, 54.0% and 51.8%. The frequency of children and adolescents with three or more risk factors was 3.4% and 4.5% among Portuguese boys and girls, respectively, and 1.9% and 4.9% among Mozambicans, but with no statistical significant difference between countries.

Differences in zCR between BMI and cardiorepiratory fitness groups are presented on graphically displayed on Figure 2. Both Portuguese and Mozambican normal weight youth have a better zCR than those with overweight/obesity. Taking account the cardiorespiratory fitness classification, fit Portuguese youth have a lower zCR; however, in the Maputo sample, no significant difference was found for zCR among fitness groups. Mozambican youth showed a higher zCR than Portuguese in both BMI and cardiorespiratory fitness groups.

DISCUSSION

The purpose of this study was to examine differences in cardiometabolic risk indicators in Portuguese and Mozambican

Table 1. Country means (M ± standard deviation) by sex for maturity offset, BMI, cardiorespiratory fitness and cardiometabolic risk indicators

	PT *M ± s.d.*	*MZ* *M ± s.d.*	*t*	P-*value*
Boys				
Maturity offset (years relative to PHV)	− 1.1 ± 1.3	− 2.2 ± 1.3	7.577	< 0.001
BMI (kg m^{-2})	20.4 ± 3.9	17.9 ± 2.9	6.524	< 0.001
1 Mile run/walk (s)	527.7 ± 125.2	639.6 ± 135.7	− 7.849	< 0.001
Waist circumference (cm)	68.5 ± 9.2	64.0 ± 7.2	5.046	< 0.001
HDL (mg dl^{-1})	50.7 ± 13.9	34.9 ± 17.5	9.105	< 0.001
Triglycerides (mg dl^{-1})	70.5 ± 42.3	67.0 ± 43.2	0.755	0.451
Glucose (mg dl^{-1})	91.1 ± 7.5	88.0 ± 12.0	2.874	0.004
SBP (mm Hg)	112.3 ± 12.2	112.8 ± 11.1	− 0.352	0.725
DBP (mm Hg)	61.3 ± 6.8	69.6 ± 8.6	− 9.803	< 0.001
MAP (mm Hg)	78.3 ± 7.9	84.0 ± 8.5	− 6.385	< 0.001
Cardiometabolic risk (*z*-score)	− 1.0 ± 2.4	1.0 ± 2.3	− 7.813	< 0.001
Girls				
Maturity offset (years relative to PHV)	0.3 ± 1.0	− 0.3 ± 1.3	4.985	< 0.001
BMI (kg m^{-2})	20.7 ± 3.5	19.2 ± 3.7	3.941	< 0.001
1 Mile run/walk (s)	624.7 ± 115.0	745.8 ± 167.8	− 7.938	< 0.001
Waist circumference (cm)	66.1 ± 7.6	67.3 ± 8.7	− 1.482	0.139
HDL (mg dl^{-1})	51.8 ± 11.8	36.9 ± 18.2	9.113	< 0.001
Triglycerides (mg dl^{-1})	86.6 ± 48.1	82.8 ± 67.4	0.659	0.511
Glucose (mg dl^{-1})	90.6 ± 12.1	86.1 ± 12.1	3.638	< 0.001
SBP (mm Hg)	111.1 ± 10.4	113.0 ± 11.0	− 1.692	0.091
DBP (mm Hg)	63.6 ± 7.5	68.4 ± 7.8	− 6.124	< 0.001
MAP (mm Hg)	79.4 ± 7.7	83.2 ± 7.8	− 4.745	< 0.001
Cardiometabolic risk (*z*-score)	− 0.8 ± 2.4	1.0 ± 2.6	− 7.017	< 0.001

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; HDL, high-density lipoprotein; MAP, mean arterial pressure; MZ, Mozambique; PHV, peak height velocity; PT, Portugal; SBP, systolic blood pressure.

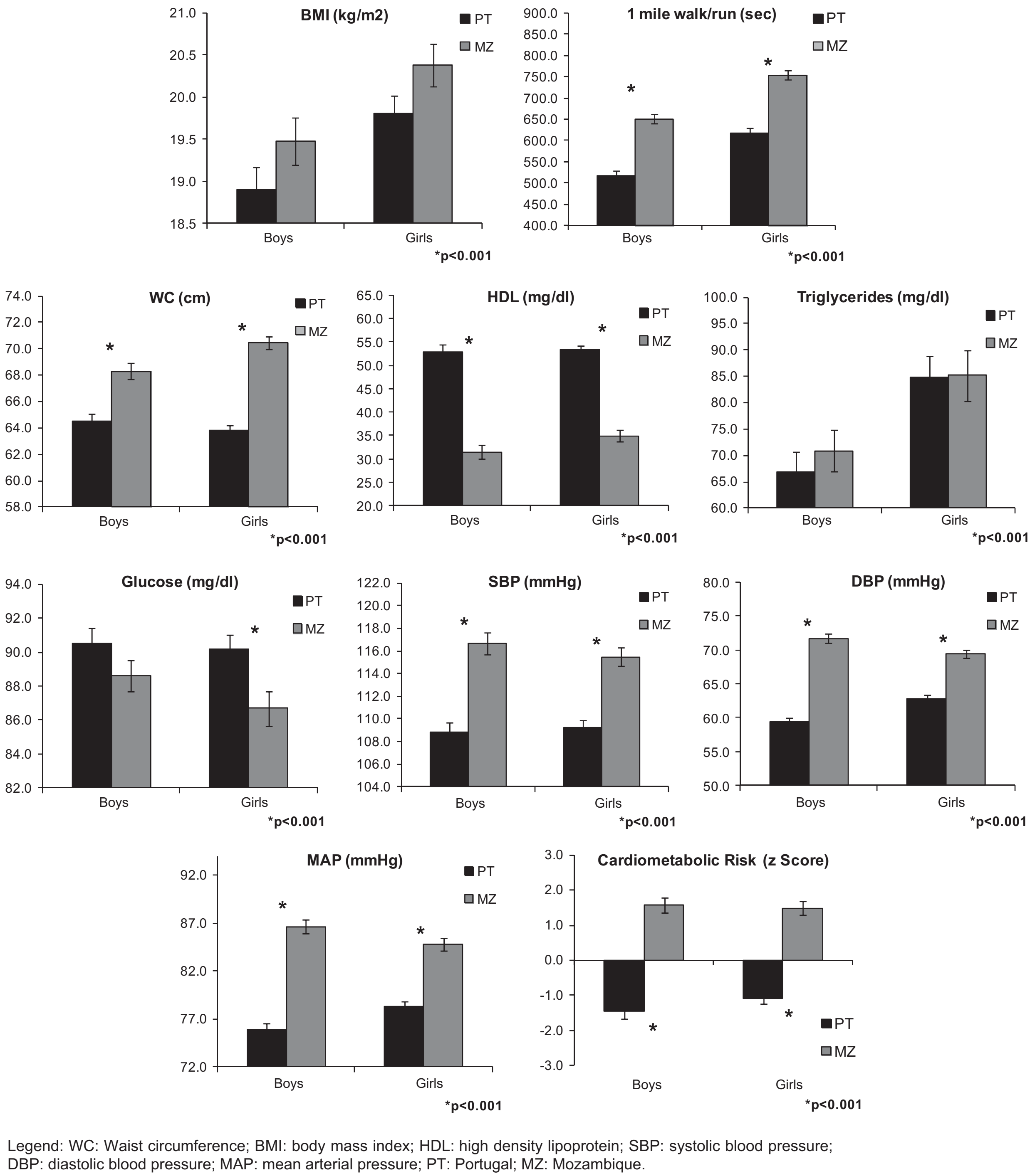

Figure 1. Country mean differences by sex in age- and maturation-adjusted cardiometabolic risk indicators, zCR, BMI and cardiorespiratory fitness.

youth, as well as the relationship of weight status and cardiorespiratory fitness levels with cardiometabolic risk in these children and adolescents. Except for BMI, triglycerides and glucose in boys, statistically significant differences were observed among Mozambican and Portuguese youth in cardiometabolic indicators, as well as in cardiorespiratory fitness.

Portuguese boys and girls are fitter than their Mozambican peers, that is, they spend less time to cover the 1-mile distance. It is possible that this result may be the outcome of a higher socioeconomic status in association with a better nutritional environment in Portugal. Although the relationship between cardiorespiratory fitness and socioeconomic status is not always clear,[33,34] social disparities between these two countries may be playing a role in these mean differences.[20,22–24,35–38] The income inequality observed in Mozambique, especially in Maputo city, even after its economic growth, may impede children from having access or opportunities to buy sports equipment, or to engage in moderate-to-high recreational physical activities offered by organized private sports' clubs. In addition, the reduction in physical activity levels, namely in household chores, subsistence,

Table 2. Country- and sex-specific frequencies for BMI and cardiorespiratory fitness groups, as well as for cardiometabolic risk indicators

		Boys						*Girls*					
		MZ		*PT*		χ^2	P-*value*	*MZ*		*PT*		χ^2	P-*value*
		n	%	n	%			N	%	N	%		
BMI groups	Normal weight	149	92.5	118	67.8	31.613	< 0.001	128	79.0	156	69.6	4.245	0.039
	Overweight/obese	12	7.5	56	32.2			34	21.0	68	30.4		
CRF groups	Unfit	74	46.0	32	18.4	29.391	< 0.001	90	55.6	50	22.3	44.922	< 0.001
	Fit	87	54.0	142	81.6			72	44.4	174	77.7		
WC	Low risk	159	98.8	162	93.1	6.676	0.010	153	94.4	211	94.2	0.011	0.917
	At risk	2	1.2	12	6.9			9	5.6	13	5.8		
HDL	Low risk	52	32.3	129	74.1	58.793	< 0.001	62	38.3	185	82.6	80.130	< 0.001
	At risk	109	67.7	45	25.9			100	61.7	39	17.4		
TRG	Low risk	154	95.7	153	87.9	6.824	0.011	139	85.8	175	78.1	3.652	0.056
	At risk	7	4.3	21	12.1			23	14.2	49	21.9		
Glucose	Low risk	157	97.5	172	98.9	0.847	0.357	159	98.1	216	96.4	1.004	0.316
	At risk	4	2.5	2	1.1			3	1.9	8	3.6		
SBP	Low risk	122	75.8	144	82.8	2.493	0.114	120	74.1	185	82.6	4.111	0.043
	At risk	39	24.2	30	17.2			42	25.9	39	17.4		
DBP	Low risk	130	80.7	171	98.3	28.182	< 0.001	138	85.2	213	95.1	11.184	0.001
	At risk	31	19.3	3	1.7			24	14.8	11	4.9		
BP[a]	Low risk	113	70.2	141	81.0	5.368	0.021	112	69.1	184	82.1	8.896	0.003
	At risk	48	29.8	33	19.0			50	30.9	40	17.9		
Nº cardiometabolic risk indicators	0	35	21.7	94	54.0	36.807	< 0.001	35	21.6	116	51.8	35.956	< 0.001
	1	85	52.8	54	31.0	16.311	< 0.001	78	48.1	79	35.3	6.463	0.011
	2	38	23.6	20	11.5	8.564	< 0.001	41	25.3	19	8.5	20.275	< 0001
	3+	3	1.9	6	3.4	0.803	0.370	8	4.9	10	4.5	0.047	0.827

Abbreviations: BMI, body mass index; BP, blood pressure; CRF, cardiorespiratory fitness; DBP, diastolic blood pressure; HDL, high-density lipoprotein; SBP, systolic blood pressure; TRG, triglycerides; WC, waist circumference. [a]At risk for SBP and/or DBP.

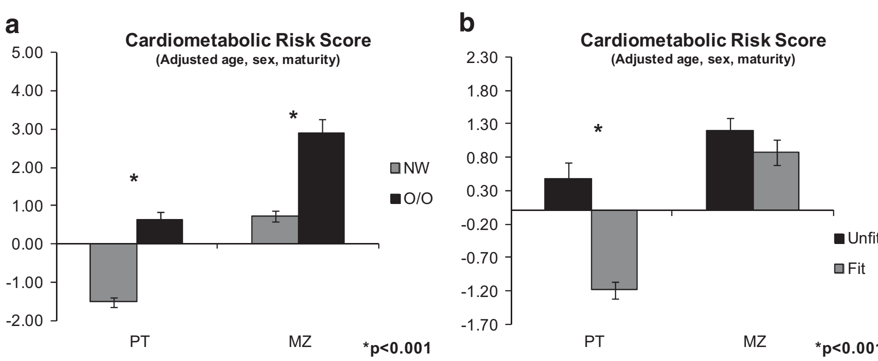

Figure 2. Mean differences in the zCR (adjusted for age, sex and biological maturity) between BMI (**a**) and cardiorespiratory fitness (**b**) groups, by country. MZ, Mozambique; PT, Portugal.

leisure time and transportation (walk) activities (unpublished data), increases in sedentary time[39] as well as rises in overweight/obesity prevalences in Mozambican youth[40] in recent decades may explain their lower performance, as physical activity[41] and body size[42,43] are related to cardiorespiratory fitness performance.

Differences in cardiometabolic indicators among ethnic groups were previously reported,[44] and a similar result was expected when comparing Mozambican and Portuguese youth. However, since it has been reported that in industrialized countries the prevalence of childhood overweight/obesity is higher than in least developed and developing, especially in African countries,[1] Portuguese children and adolescents were expected to have a worse cardiometabolic profile than Mozambicans, but the present results show exactly the opposite—children from Maputo have, in general, worse cardiometabolic profiles. It is now recognized that the urbanization process resulted in changes in human demography, industrial structure, income and education levels, family structure and lifestyle (physical activity, sedentariness and nutritional habits), which are related to increases in cardiometabolic risk factors and cardiovascular diseases.[45] This is a major global health problem with the majority of the burden occurring in least developed and developing countries, and are attributable to increases in the incidence of atherosclerotic diseases, probably due to the age at onset, the large population size and the high prevalence of young adults or middle-aged population in these nations with this problem.[46] The demographic (shift to low fertility, low mortality and higher life expectancy) and the epidemiologic (from widely infectious diseases to a high prevalence of non-communicable diseases) transitions that occurred in least developed and developing countries induced modifications in dietary and physical activity patterns, with significant effects on body composition and metabolism, usually resulting in BMI increases, excess adiposity, deposition of ectopic fat, dyslipidemia and diabetes.[44] In addition, as poverty increases the vulnerability to exposure to behavioral risk factors, the probability of dying from cardiovascular disease prematurely is higher in least developed and developing nations.[47] Poverty limits the choices of healthy foods, decreases the consumption of fruits, vegetables, low-fat meat and dairy products,[48] as well as increases the crime rate, which limits places for children to be physically active; on the contrary, it seems to augment sedentary activities like screen time.[44] Regarding the role of the urbanization process on health in least developed and developing countries, Yusuf *et al.*[46] reported an increase in daily energy and protein intake in China from the1950s to the 1980s, followed by a period of stability from the 1980s to the1990s in total energy intake, but changes in diet composition led to decreasing the consumption of carbohydrates and increasing the proportion of energy provided by fat and the consumption of animal products. These changes, which have coincided with increases in obesity, hypertension, cholesterol and glucose level, and decreases in insulin sensitivity, are associated with the high prevalence of cardiovascular diseases, and have been also observed in Sub-Saharan African context. In South Africa, for example, the high rates of urbanization and poverty, with the migration of people to urban centers, has increased prevalence of obesity, hypertension and hypercholesterolemia.[45] Similarly, the rural to urban migration process was also related to increases in obesity and other cardiovascular risk factors in children from Brazil and India, whereas this process led these migrants to live in urban slums and city shantytowns, which exposes them to urbanized diet and lifestyle.[44] In the Mozambique context, the urbanization process led to migration from rural to urban areas (which is related to increases in obesity and other cardiovascular diseases in these migrants[44]), and potentially led to increases in the consumption of high energy-dense food and increases in sedentariness. Furthermore, this process also led to a decrease in leisure time and total physical activity levels of its population. This rapid lifestyle transition may be related to the results found in this study, and could explain the worse cardiometabolic risk profile observed in these youth, when compared with Portuguese youth.

More than 30% of Portuguese boys and girls were classified as overweight or obese, as opposed to 7.5% and 21% found among urban Mozambicans, respectively. Notwithstanding an increase in the prevalence of overweight/obesity in least developed and developing countries during the last years, the prevalence remains higher in industrialized nations.[1] The observed differences in cardiometabolic risk between Portuguese and Mozambican youth may be explained by the fact that these countries are at different stages of epidemiologic transition. For example, Mozambique may be in the fourth stage of transition, characterized by affluence and the consumption of diets high in saturated fats, cholesterol, refined carbohydrates, low polyunsaturated fatty acids and fiber, and adopting a markedly sedentary lifestyle.[44] On the other hand, Portugal is probably in the fifth stage of transition, where the prevalence of obesity, cardiometabolic risk and co-morbidities are already high, but people are becoming aware of the benefits of balanced diets and physically active lifestyles, and as a consequence are changing their diets and physical active habits aiming to prevent or delay these diseases.[44] As such, the prevalence of childhood overweight/obesity in Mozambique is expected to increase in the next years, whereas in Portugal, this prevalence seems to have reached a plateau in some age groups[49] and a possible decline may occur in the next decades.

As a probable consequence of their higher prevalence of overweight/obesity, Portuguese boys showed higher risk for waist circumference and triglycerides than their Mozambican peers. As waist circumference is related to BMI,[50] this result was expected. Concerning triglycerides, two possible explanations may be advanced. First, there is a known relationship between excess weight and hypertriglyceridemia.[51] Second, in general, Africans seem to be the less likely to have elevated triglycerides compared with European populations.[52]

Mozambican youth showed higher risk for elevated blood pressure and low HDL than the Portuguese youth. Previous studies noted a marked tendency for hypertension in African populations,[53] and in Mozambique, a high blood pressure prevalence in the adult population has been observed.[54] A similar trend may be seen in youth as previously reported among rural Mozambican children.[55] The higher risk prevalence for low HDL in Mozambicans, as compared with Portuguese, may be associated with a tendency for African people to have low HDL values,[52,56] which can be attributed to the urbanization of African populations and the attendant changes in diet and exercise.[56] No significant differences were found in the prevalence of cardiometabolic syndrome (three or more risk factors) among Mozambican and Portuguese samples.

In general, normal weight and physically fit children have a lower zCR than those who are overweight/obesity and unfit, respectively, but these differences are not always statistically significant. The prevalence of cardiometabolic risk indicators rises in children in parallel with childhood obesity increases,[6] pointing to a strong relationship between high BMI and cardiometabolic risk. Previous studies have shown that obese children and adolescents have higher cardiometabolic abnormalities than normal weight youth,[5,6] which reinforces the negative impact of excess weight on youth cardiometabolic health. Our results are consistent with this evidence as both Mozambican and Portuguese youth classified as having a normal weight had a lower zCR, when compared with those with overweight/obesity. Notwithstanding some evidence pointing to higher cardiorespiratory fitness as a protective factor for cardiometabolic abnormalities,[12] this association was not clearly demonstrated in the present study. A significant negative association was found between cardiorespiratory fitness and zCR in Portuguese youth, but no significant association was found in the Mozambican sample. Previous studies also did not find any significant associations between cardiorespiratory fitness and cardiometabolic indicators in children,[57] even in Mozambican children.[55]

This study is not without limitations. First, we did not include information on physical activity levels, which could be helpful to better understanding the results, given the relationships between physical activity, excess weight and cardiorespiratory fitness. Second, the samples did not represent children and adolescents from each country. As such, the degree to which the results are generalizable is not known. Third, notwithstanding the same measurement protocol, it was not possible to use the same measurement devices in both countries. However, there is available information related to the cross-validation of the blood analysis machines[58] and the blood pressure machines[59,60] used in the study. Despite these limitations, this study also has several significant merits. It tackles an important epidemiological issue in children and adolescents health and lifestyles; it sampled from two different countries with different socioeconomic profiles, providing information on cardiometabolic risk profiles and their relationship with overweight or obesity and physical fitness in these diverse samples.

In conclusion, the present study showed that Portuguese and Mozambican youth differ in their cardiometabolic risk profiles, their body weight and cardiorespiratory fitness. In general, Portuguese children and adolescents showed better cardiometabolic and cardiorespiratory fitness profiles. The relationship between BMI and cardiorespiratory fitness with cardiometabolic risk showed that irrespective of country, excess weight is linked to a worse cardiometabolic profile; however, for Portuguese youth, better cardiorespiratory fitness was associated with lower cardiometabolic risk, but this finding was not replicated among Mozambican children. These results highlight that the urbanization process and stage of epidemiologic transition may be important factors in explaining population differences in cardiometabolic risk factors. As obesity and cardiometabolic abnormalities track well from childhood and adolescence to adulthood, it is relevant to design more efficient public health intervention strategies to reduce these risk factors as early in life as possible to reduce the incidence of cardiovascular diseases later in life.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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