Physical activity, fitness and the metabolic syndrome in rural youths from Mozambique

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Background: Except for North America and Europe, few studies have reported the association among physical activity (PA), cardiorespiratory fitness (CRF) and metabolic syndrome (MetS) in youths, especially for rural African youth.

Aim: The aims of this study were to determine the prevalence of PA levels, CRF, MetS and its indicators, and examine the association between these variables in a school-aged sample of youth from rural Mozambique.

Subjects and methods: The sample included 209 children and adolescents aged 7–15 years old from Calanga, a rural community in Mozambique. PA was estimated with a culturally-specific questionnaire. CRF was determined by 1-mile run test. Indicators of the MetS included fasting glucose, triglycerides, total cholesterol, blood pressure and body mass index. A continuous metabolic risk score was computed.

Results: Results showed high levels of PA and CRF and a low prevalence of MetS (≤2%) among children and adolescents from Calanga. However, there was a moderately high prevalence of elevated blood pressure (81.8%) and triglycerides (18.7%), respectively. There were no significant associations between PA, CRF and MetS.

Conclusion: Youths from Calanga are physically active and possess high CRF and their lifestyle may be a protective effect against MetS.

Keywords: Metabolic risk, cardiorespiratory fitness, active lifestyle

BACKGROUND

The increase of obesity and related co-morbidities including the metabolic syndrome (MetS) in the last 50 years have been attributed to the reduction of physical activity (PA) levels induced by changes in lifestyle, especially among Western cultures (Cook 2004; Malina and Little 2008). By clinical definition, the MetS is a cluster of three or more of the following metabolic abnormalities: abdominal obesity, high blood pressure, dyslipidemia and dysglycemia (Alberti et al. 2006). Despite the lack of a universal definition of MetS in youth, several studies have reported its prevalence in children and adolescents from both developed and developing countries with values ranging between 0–60% (Huang et al. 2007).

In several African countries, where most people live on a basis of subsistence-level farming, infant under-nutrition is still quite prevalent (Saranga et al. 2007) and the high prevalence of infectious diseases is related to poverty (Nhantumbo et al. 2007). Recently, the increased level of urbanization has led to a higher prevalence of MetS indicators in children and adolescents from the Seychelles and Equatorial Guine (Chiolero et al. 2009; Custodio et al. 2010).

Overweight and obesity are strongly related to the prevalence of MetS in children and adolescents (Saland 2007). Among youths from urbanized African populations, an increase in overweight and obesity has been observed in the past 15 years (Chiolero et al. 2007, 2009; Longo-Mbenza et al. 2007; Mamabolo et al. 2007; Otinwa 2009), as well as decreases in PA levels (Saranga et al. 2002; Mamabolo et al. 2007). Furthermore, changes in lifestyle associated with urbanization led to a higher prevalence of high blood pressure in this stratum of population (Agyemang et al. 2005; Ejike et al. 2008), which represents an important component of MetS.

In spite of changes in behavioural and nutritional habits occurring in urbanized African population, it is generally
accepted that an urban–rural gradient exists in the lifestyles and environmental conditions (Dapi et al. 2005; Ntandou et al. 2008). It is expected that the lifestyle of rural youths is linked to protective factors against cardiovascular disease (CVD). In contrast to urbanized children and adolescents, rural youths spend more time on daily PA (such as household chores), their nutrition habits are not yet affected by industrialization and they do not spend any time on television, computers or video games (i.e. screen time) because they cannot afford them and no cable or electricity facilities are available. However, despite these differences in lifestyle among rural and urbanized youths, which may lend to the conclusion that rural youth are ‘protected’ from indicators of metabolic risk, recent studies indicate that the prevalence of some metabolic risk factors are also increasing in this population (Kitange et al. 1993), with rates of overweight/obesity and high blood pressure reported among children and adolescents from rural Africa between 0.6–25% (Kitange et al. 1993; Monyeki et al. 2006; Kimani-Murage et al. 2008). It is expected that the lifestyle of rural youths is different from that of urbanized children and adolescents, although this type of association may not be present, as shown by Shaibi et al. (2005), who could not find any association between them. Despite the interest in this topic, few studies have reported this relationship in African youths and information for rural African youths is particularly lacking. Given the lack of studies in rural Mozambique youth, the present investigation has been carried out to: (1) report the prevalence of metabolic risk factors and, in turn, the prevalence of MetS in a school-aged sample from rural Mozambique; (2) determine PA levels and CRF among these youth; and (3) examine the association between PA, CRF and metabolic risk factors in rural Mozambique youth.

METHODS

Subjects

This study is part of a Mozambican research project entitled ‘Human Biological Variability: Implications for Physical Education, Sports, Preventive Medicine and Public Health’ (HBV) and was conducted in Calanga, a rural area on the eastern coast of southern Mozambique. This region has high endemicity and transmissibility of malaria. The main occupation of its inhabitants is subsistence-level farming, raising cattle and handicraft and a smaller part of the population (mainly adults) works as seasonal sugar cane cutters as well as fishermen; the mains source of income comes from familial agricultural practices. Data was collected in August 2005, during the dry-season and, at the time of the data collection, the houses were precarious, the region is not served by electricity, water, sanitation or roads and there was no medical assistance. The estimated population of Calanga was 9451 inhabitants (3361 from 6–20 years of age (INE 1997)) who live in small rural communities scattered around the region.

From the original HBV sample of 845 youths aged 6–20, children and adolescents attending the 1st or 2nd levels of the primary school (aged 6–17 years) were selected. By the fact that the number of subjects aged 6 years or above 15 years was low, the sample comprised youths aged between 7–15 years and was further restricted to individuals with complete data on all variables of interest, resulting in a final sample of 209 youth. A little test for missing completely at random (MCAR) was performed in each variable in every cohort using SYSTAT 13. Furthermore, we did not observe significant differences between those who remained in the study and those who had missing values in main variables. Since the economical conditions, parental education and social status are very similar among these children, no bias was identified in our sampling. All subjects were recruited from local schools. The study was approved by the National Committee for Bioethics from Mozambique. The purpose of the study was communicated officially and traditionally in advance to local authorities, parents and teachers at the schools. Informed consent was obtained from parents. All procedures were explained to the youths during data collection.

Anthropometry

Height and weight were measured by trained physical education graduate students of both sexes, so that girls were evaluated only by women and boys only by men. Height was measured with a Harpenden stadiometer (± 0.1 cm; Holtain, Crymych, UK) and children were assessed without shoes. Subjects were weighted naked in a private environment using a Seca scale (± 0.1 kg). Anthropometric measurements were done according to the procedures described by Lohman et al. (1988). The body mass index (BMI, kg/m²) was calculated from measured height and weight.

Blood pressure measures

Resting blood pressure was determined on the left arm using a digital Omron sphygmomanometer after subjects had been seated for 10 min of rest. Two measures were taken with a 3-minutes interval between successive measurements. If the difference between the first and second measurement, either diastolic (DBP) or systolic blood pressure (SPB), was greater than 10 mm Hg, a third measurement was taken. All measurements were taken by the same health professional trained by one of the co-authors who is a cardiologist.
Physical activity and cardiorespiratory fitness

Habitual PA was estimated with a questionnaire developed and validated for children and youth of Mozambique (Prista et al. 2000). The questionnaire was applied in an individually based interview and subjects were asked how many times per week they performed the activities included in the questionnaire. The questions are classified in four domains: household tasks, sports, playing and walking activities. An individual activity coefficient (AC) was determined as the sum of the products of the estimated energy cost of each activity (in METs) multiplied by the number of times per week each subject performed each activity, which was used to estimate energy expenditure in METs or to classify subjects into distinct activity groups.

CRF was estimated by the 1-mile run test (1MRT) (Safrit 1995). The test was applied on a hard surface track around a thick sand soccer field. Prior to the test, a practice session was conducted aiming to instruct children and adolescents about pace and distance perception. Team members were placed around the track to motivate children to perform at their best.

Blood samples

Ten millilitres of venous whole blood was obtained from all participants who consented to the study. The blood was collected into a 5-ml vacuum tube with K3EDTA and 5-ml Serum Separation Tube (BD Vaccutainer, Franklin Lakes, NJ, USA). The blood was delivered to the laboratory within 6 h of collection in an appropriate laboratory cooler container. Upon delivery at the laboratory, all Serum Separation Tubes were centrifuged and the serum was aliquoted into 2-ml tubes to perform biochemistry analysis. Serum concentrations of fasting glucose, triglycerides and total cholesterol were determined using an automated spectrophotometric instrument (NExCT™, Alfa Wasserman Diagnostic Technologies, Woerden, Netherlands) and commercial reagents (Cholesterol, Alfa Wassermann, Netherlands). All blood samples were processed within 8 h of collection.

Because the definition of MetS has not yet been formally established in children and given the indicators variables in the study, an adaptation to define the MetS was used based on cut-off points suggested by Cook et al. (2003) (fasting glucose, triglycerides and SBP), by the International Obesity Task Force (Cole et al. 2000) (BMI) and by the Brazilian Society of Cardiology (Sociedade Brasileira de Cardiologia 2005) (total cholesterol); due to budget constraints, HDL-cholesterol was not assessed. The MetS was defined when at least three of the following abnormalities were present in any subject: a serum fasting glucose of at least 110 mg/dl; triglycerides of at least 110 mg/dl; total cholesterol of at least 170 mg/dl; systolic or diastolic blood pressure ≥90th percentile adjusted for height, age and gender; and obesity defined as age- and gender-specific cut-off points.

Maturity assessment

All children and adolescents were assessed for their biological maturity based on sexual secondary characteristics (pubic hair stages) (Tanner and Whitehouse 1982). All assessments were done by the same trained team members.

Statistical analysis

All variables were normally distributed within groups with the exception of triglycerides, BMI and 1MRT, which were log transformed before further analysis. For clarity, the actual data are presented. Descriptive statistics (mean and standard deviation (SD)) for all indicators of the MetS were calculated by sex. A standardized continuously distributed variable (standardized metabolic risk score—zMetS) for clustered metabolic risk was calculated. This variable (zMetS) was derived by standardizing and then summing the continuously distributed MetS components (BMI, fasting glucose, triglycerides, total cholesterol, SBP and DBP). A lower score is indicative of a better CVD risk factor profile. PA and 1MRT were analysed as tertiles within each sex, where third tertile represents more active and/or fitter subjects and the first tertile represents less active and/or fit ones.

Sex differences were assessed with independent t-tests. A stepwise regression analysis was used to adjust 1MRT to height, weight, age and maturational status. Similarly, zMetS was adjusted for maturational status. The association between zMetS and PA tertiles and between zMetS and 1MRT tertiles was assessed by analysis of variance (ANOVA). SPSS version 18.0 was used in all analyses and the significance level was set at 5%.

RESULTS

Descriptive characteristics by sex for physical measures, indicators of the MetS, PA and 1MRT are presented in Table I. Boys have lower blood pressure (SBP: \( t = -2.114, p = 0.036 \)), possess higher CRF (\( t = -3.237, p = 0.001 \)) and are less physically active (\( t = -3.244, p = 0.001 \)) than girls; and girls were shown to be more mature than boys (\( t = -5.574, p < 0.001 \)). No statistical significant differences were observed for the other variables.

Using the suggested Fitnessgram cut-points (Safrit 1995), only 4.8% of the children were below the healthy zone for the 1MRT (95.2% of subjects are in the healthy zone). Since Fitnessgram suggests 1MRT cut-off points for children aged 10 years or above (children aged 5–9 years have only to complete the test, independently of the time needed to cover the distance, to be considered in the healthy zone), 66 (48.5%) children between 10–15 years (a total of 136 children) were even above the healthy zone because their performance (time spent to conclude the 1MRT) was below the minimum values used to classify children in the healthy zone, which means that their performance was far superior than those expected for their age and sex.

Among the MetS-indicators, triglycerides and blood pressure had the highest prevalence. The overweight prevalence was only 1% (data not showed) and the prevalence of obesity was 0% (Table II). Overall, the prevalence of MetS is almost inexist; 85.6% of the
DISCUSSION

The purpose of this study was to examine the prevalence of metabolic risk factors, PA and CRF levels and their associations in school children aged 7–15 years from Calanga, a rural community in Mozambique. Calanga has cultural, social, economic and environmental features which makes it widely different from any western localities. For example, children spend most of their time engaged in subsistence activities (household chores and farming activities), walk for long distances (going to and from school, carrying food and water) and they do not watch TV or play electronic games because they do not exist there. In their leisure time, they are engaged in outdoor and popular games (Prista et al. 2009).

As may be expected, high levels of PA and CRF levels were observed in both boys and girls. Similar results were found by Prista et al. (2009) and Nhantumbo et al. (2007), whose studies reported, respectively, high PA (measured by accelerometer and the same questionnaire used in the present studies) and high CRF (measured by 1MRT) levels among Mozambican youth. In contrast to the well-documented sex-difference in PA (boys more active)

Table I. Sex-specific descriptive statistics (means and SDs) for physical, metabolic and fitness characteristics, t- and p-values, for mean differences.

<table>
<thead>
<tr>
<th></th>
<th>Boys, Mean ± SD</th>
<th>Girls, Mean ± SD</th>
<th>t</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n = 93)</td>
<td>(n = 116)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>10.76 ± 2.46</td>
<td>10.99 ± 2.47</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>132.57 ± 8.45</td>
<td>136.34 ± 14.84</td>
<td>–1.919</td>
<td>0.056</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>29.09 ± 8.45</td>
<td>31.30 ± 9.91</td>
<td>–1.714</td>
<td>0.088</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>16.19 ± 1.72</td>
<td>16.39 ± 2.18</td>
<td>–0.760</td>
<td>0.448</td>
</tr>
<tr>
<td>Maturational status (pubic hair stages)</td>
<td>1.13 ± 0.45</td>
<td>1.66 ± 0.83</td>
<td>–5.574</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fasting glucose (mg/dL)</td>
<td>76.78 ± 8.23</td>
<td>77.01 ± 9.52</td>
<td>–1.188</td>
<td>0.851</td>
</tr>
<tr>
<td>SBP (mm Hg)</td>
<td>106.27 ± 10.51</td>
<td>109.47 ± 11.30</td>
<td>–2.114</td>
<td>0.036</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td>63.58 ± 9.83</td>
<td>65.01 ± 9.31</td>
<td>–1.071</td>
<td>0.285</td>
</tr>
<tr>
<td>Total cholesterol (mg/dL)</td>
<td>113.31 ± 24.55</td>
<td>115.72 ± 24.64</td>
<td>–0.704</td>
<td>0.482</td>
</tr>
<tr>
<td>Triglycerides (mg/dL)</td>
<td>88.36 ± 34.27</td>
<td>86.18 ± 32.76</td>
<td>0.466</td>
<td>0.642</td>
</tr>
<tr>
<td>PA (AC)</td>
<td>115.84 ± 31.47</td>
<td>130.26 ± 32.50</td>
<td>–3.244</td>
<td>0.001</td>
</tr>
<tr>
<td>1MRT (minutes)</td>
<td>8.36 ± 1.02</td>
<td>8.98 ± 1.59</td>
<td>–3.237</td>
<td>0.001</td>
</tr>
</tbody>
</table>

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; PA, physical activity; AC, activity coefficient; 1MRT, 1-mile run test.

Table II. Sex-specific frequencies of the metabolic risk factors.

<table>
<thead>
<tr>
<th></th>
<th>Boys (n = 93)</th>
<th>Girls (n = 116)</th>
<th>Total (n = 209)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Without risk</td>
<td>93 (100%)</td>
<td>116 (100%)</td>
<td>209 (100%)</td>
</tr>
<tr>
<td>Glucose</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk</td>
<td>0 (0.0%)</td>
<td>1 (0.9%)</td>
<td>1 (0.5%)</td>
</tr>
<tr>
<td>Without risk</td>
<td>93 (100%)</td>
<td>115 (99.1%)</td>
<td>208 (99.5%)</td>
</tr>
<tr>
<td>BP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk</td>
<td>72 (74.4%)</td>
<td>99 (85.3%)</td>
<td>171 (81.8%)</td>
</tr>
<tr>
<td>Without risk</td>
<td>21 (22.6%)</td>
<td>17 (14.7%)</td>
<td>38 (18.2%)</td>
</tr>
<tr>
<td>Cholesterol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk</td>
<td>2 (2.2%)</td>
<td>3 (2.6%)</td>
<td>5 (2.4%)</td>
</tr>
<tr>
<td>Without risk</td>
<td>91 (97.8%)</td>
<td>113 (97.4%)</td>
<td>204 (97.6%)</td>
</tr>
<tr>
<td>Triglycerides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At risk</td>
<td>16 (17.2%)</td>
<td>23 (19.8%)</td>
<td>39 (18.7%)</td>
</tr>
<tr>
<td>Without risk</td>
<td>77 (82.8%)</td>
<td>93 (80.2%)</td>
<td>170 (81.7%)</td>
</tr>
</tbody>
</table>

BMI, body mass index; BP, blood pressure. Cut-points used: BMI: age- and sex-specific (Cole et al. 2000); Glucose: ≥110 mg/dl (Cook et al. 2003); BP: ≥90 (Cook et al. 2003); Cholesterol: ≥170 mg/dl (Sociedade Brasileira de Cardiologia 2005). Triglycerides: ≥110 mg/dl (Cook et al. 2003).
Table III. Differences across tertiles of the continuous standardized metabolic risk score of physical activity and cardiorespiratory fitness among boys and girls.

<table>
<thead>
<tr>
<th>Tertile</th>
<th>Power</th>
<th>Trend</th>
<th>Tertile 1</th>
<th>Tertile 2</th>
<th>Tertile 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
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<tr>
<td></td>
<td></td>
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<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(unadjusted)</td>
<td>adjusted for height and maturity status)</td>
<td>(adjusted for maturity status)</td>
</tr>
<tr>
<td>Physical Activity</td>
<td>zMetS</td>
<td>zMetS</td>
<td>zMetS</td>
<td>zMetS</td>
<td>zMetS</td>
</tr>
<tr>
<td>1-mile run test</td>
<td>0.84 ± 2.32</td>
<td>0.19 ± 1.03</td>
<td>1.01 ± 2.81</td>
<td>0.53 ± 2.34</td>
<td>0.53 ± 0.47</td>
</tr>
<tr>
<td>1MRT (unadjusted)</td>
<td>1.476</td>
<td>0.234</td>
<td>0.308</td>
<td>0.305</td>
<td>0.339</td>
</tr>
<tr>
<td>1MRT (adjusted for height) and zMetS (adjusted for maturity status)</td>
<td>0.234</td>
<td>0.308</td>
<td>0.305</td>
<td>0.339</td>
<td>0.235</td>
</tr>
</tbody>
</table>

In spite of the global trend for an increase in MetS among youth (Huang et al. 2007; Moraes et al. 2009), the prevalence found in Calanga was < 2%. Despite the absence of obesity and low rates of high values of glucose and cholesterol, there was a high prevalence of elevated blood pressure and a moderate prevalence of elevated triglycerides. High blood pressure in African rural children and adolescents has been previously observed in Ghana (Agyemang et al. 2005) and South Africa (Monyeki et al. 2006, 2008), suggesting that the protective effect against high blood pressure in rural Africa is fading. It is possible that the high prevalence of elevated blood pressure among Calanga youth could be due to either (1) the cut-off points used were developed using samples from several populations but have not been validated for African children and (2) an eventual stress due to the ‘white coat’ effect. Moreover, it has been noted that there is a tendency for high blood pressure in African adults and this tendency may also be present in Calanga children (Cooper and Rotimi 1999; Damasceno et al. 2009). The relatively high prevalence of elevated triglycerides was unexpected because Africans seem to be less likely to have elevated triglycerides (Sumner and Cowie 2008; Sumner 2009). Nutritional habits may explain this observation as this population reports a high intake of carbohydrates (such as rice, corn and tubers) (Prista et al. 2010), which is related to high carbohydrate-induced hypertriglyceridemia (West et al. 1990; Parks 2001).

There is evidence that PA and CRF are negatively correlated to MetS (Eisenmann et al. 2005, 2007a, b; Steele et al. 2008). However, in the present study this association was not always clear. Except for the direct association between the 1MRT performance (unadjusted for height) and the zMetS for boys and between PA and the zMetS (adjusted or unadjusted) for girls, no other statistically significant association was found. These results are in contrast to most, but not all, previous studies, where in general this association is negative, with more active and fitter youth reporting a better profile for the development of the metabolic risk. However, similar results have been found in Calanga was (Ndiaye 2005).
reported. For example, Shaibi et al. (2005) did not find an association between CRF and MetS risk after controlling for differences in confounding variables. Casazza et al. (2009) also reported associations between PA and some of the metabolic risk indicators, but did not find an association between PA and MetS. This peculiarity result observed may be related to factors other than PA or CRF, since children reported high PA and CRF levels. These youngsters may be prone to develop MS, as there is some evidence that the metabolic risk tracks relatively well throughout adolescence into adulthood, although this was reported in USA subjects (Eisenmann et al. 2004).

Regardless of the importance of this data on a unique population, this study has limitations. First, self-reported PA via questionnaire can be prone to errors. Nonetheless, the use of a culturally validated instrument assessing different facets of daily PA of Mozambican children is a positive aspect. Second, distance runs to evaluated CRF have been challenged (Rowland et al. 1999; Castro-Pinero et al. 2010). One of the most important issues relates to pace as well as instrument validity (Rowland et al. 1999), although no such information is available in African children. Cureton et al. (1995) developed a prediction equation to transform raw data (age, sex, BMI and run time) into estimated VO2 max. Since it has never been cross-validated in different cultures, less so in Africa, we chose not to apply it herein. Third, the inexistence of cut-off points to define MetS specific for African children may hinder the present results. In fact, our putative cut-off values may over-estimate or under-estimate the prevalence of some metabolic risk factors and the use of another criteria may change the results, as shown in earlier studies that the use of different criteria provide quite variable prevalence rates (Reinehr et al. 2007; Braga-Tavares and Fonseca 2010). Fourth, we are aware of some loss of sensitivity due to sample data tertile division. On the other hand, we gain more insight about differences in data distribution classes defined by quantiles as is common in epidemiological research (Brage et al. 2004; Anderssen et al. 2007; Janssen and Cramp 2007; Kelishadi et al. 2007; Ruiz et al. 2007). Furthermore, it has to be acknowledged that all categorization of data is always sample-specific. Finally, we did not take into account nutritional habits, which can further explain the prevalence (or not) of some metabolic risks.

In conclusion, MetS in children and adolescents from Calanga is almost absent. Although there was no statistical relationship between PA or CRF and MetS, it is likely that a physically active lifestyle and a high level of CRF are important protecting agents against metabolic risk factors since very few children and adolescents had the MetS. PA patterns in this population are linked to survival activities, such as household chores and walking, which may explain the high frequency but low-to-moderate intensity of their activities. On the other hand, there is a high prevalence of high blood pressure and a moderate prevalence of high triglycerides. Taken as a whole these results suggest that the lifestyle of rural African youths, characterized by engaging in daily PA and traditional nutritional habits, may be a protective agent against the development of indicators of MetS. The implications of these findings on the growing obesity and MetS epidemic in other countries deserve attention.

ACKNOWLEDGEMENTS

This work was supported by funds from the World Bank Quick Impact Fund through the Higher Education Project-I of the Mozambican Ministry of Science and Technology.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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