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URBAN-RURAL CONTRASTS IN CARDIO-RESPIRATORY FITNESS, PHYSICAL ACTIVITY, INACTIVITY, AND SEDENTARY BEHAVIOUR IN PORTUGUESE ADOLESCENTS

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ABSTRACT

Background: Research considering physical activity (PA), physical inactivity, and health outcomes among urban and rural youth has produced equivocal findings.

Purpose: This study examined PA, physical inactivity, sedentary behaviours and cardiorespiratory fitness (CRF) in adolescents from urban and rural communities in the Portuguese Midlands.

Methods: The sample included 362 adolescents (165 males, 197 females) 13 to 16 years of age. CRF was assessed by the PACER test. A GT1M accelerometer was used to record five consecutive days of PA and time spent sedentary. Analyses of covariance (chronological age as co-variate) were performed to test the effect of the area of residence on sedentary behaviour, PA and CRF.

Results: Urban youth of both sexes spent less time in sedentary activities than rural youth. Urban males were more active than rural peers on the weekend, whereas urban females were significantly less active than rural females on week days and across all days assessed. Rural youth of both sexes had higher levels of CRF than urban youth.

Conclusion: Area of residence was related to aerobic fitness, PA and time spent in sedentary behaviours among Portuguese youth. Interventions seeking to enhance health and active lifestyles in Portuguese youth should consider the potential impact of socio-geographic factors.

Keywords: aerobic fitness, urbanization, accelerometry, screen time, adolescence

INTRODUCTION

Urbanization refers to the concentration of people in towns/cities and associated changes – economic transformation, migration, shifting residential patterns, and behavioural changes (Ezzati *et al*. 2005). The proportion of the world's population living in urban areas has increased dramatically over the past half century. A similar trend has been evident in Portugal over the last four decades; more than 45% of the population presently lives in the metropolitan areas of Lisbon and Oporto (Barreto 2000). The trend reflects a shift from an agricultural- to a service-based economy. Social inequalities between urban and rural communities have also become increasingly apparent, especially regarding health and educational resources (Barreto 2000).

Interest in rural health issues and health promotion has increased over the past few years. In general and in particular compared to urban communities, rural communities have limited access to health care, suffer more preventable morbidity and mortality, and have lower numbers and diversity in specialty of health professionals per population (Muula, 2007). Variables related to lifestyle, educational and economic features of the geographic context are commonly highlighted as having an important impact on public health (Barreto, 2000). Given that the potential effects of urbanization on PA, sedentary behaviours and physical fitness, and consequently on health status and promotion, further research is needed to improve understanding of CRF and active or inactive lifestyles relative to weight status in urban and rural populations in order to develop potential community, educational and perhaps clinical programs.

Urbanization is periodically highlighted as a factor that influences physical activity (PA), sedentary behaviours, weight status, and cardiorespiratory fitness (CRF) in youth. It has been intuitively assumed that individuals living in urban centres would be less active than their rural counterparts, and by inference would have lower levels of CRF and higher levels of overweight and obesity (Liu *et al*., 2008; Spring *et al*., 2006; Albarwani *et al*., 2009; Ismailov and Leatherdale, 2010). Research dealing with the impact of urbanization on PA, physical inactivity, CRF and health, however, has not been entirely consistent (Cicognani *et al*. 2008). In addition to variable definitions of urban and rural, potential confounders include local cultural and social factors, climate and methods of assessment so that it is difficult to generalize socio-geographic variation in activity and inactivity behaviours, CRF and associated health outcomes across countries. It is also possible that health outcomes associated with urban-rural residence vary differentially across geographic regions (i.e., North Europe, Mediterranean countries, North America, Asia, Latin America).

Higher levels of overweight and obesity have been noted among rural compared to urban school youth in the U.S. (Liu *et al*. 2008; Lutfiyya *et al*. 2007), Canada (Ismailov and Leatherdale 2010), and Spain (Moreno *et al*. 2001). In contrast, adolescents from urban communities were more likely to be overweight and obese than rural peers in China (Xu *et al*. 2007) and Oman (Albarwani *et al*. 2009). Rural adolescents of both sexes were less physically active than urban youth in the U.S. (Liu *et al*. 2008; Lutfiyya *et al*. 2007) and Iceland (Kristjansdottir and Vilhjalmsson 2001; Lutfiyya *et al*. 2007). The opposite trend was noted in Oman (Albarwani *et al*. 2009) whereas urban-rural differences in moderate-to-vigorous PA were negligible in Taiwanese youth (Huang and Malina 1996). Urban youth in the U.S. were more likely to be sedentary than rural youth (Liu *et al*. 2008) and within the U.S., school youth resident in the South had the lowest prevalence of PA and highest prevalence of TV viewing compared youth in the Western region (Springer *et al*. 2006). In Sweden, on the other hand, youth from different regions did not differ in active behaviours (Sjolie and Thuen 2002).

Trends in physical fitness show more variable contrasts. Youth from rural communities were more likely to be classified as physically fit, especially in CRF, compared to urban youth in Oman (Albarwani *et al.* 2009). On the other hand, differences in several motor fitness and somatic characteristics between rural and urban Belgian youth were negligible (Taks *et al.* 1991). The authors attributed the observations to an ongoing process of conurbation in Belgium, which is a relatively small country geographically. Among relatively impoverished Mexican school youth, those resident in an urban colonia had somewhat better endurance performance (distance run) compared to peers from an impoverished indigenous rural community (Reyes *et al.* 2003).

Presently available data relating urbanization to PA, sedentary behaviour and CRF indicate somewhat variable results within and among specific countries and regions. Research addressing the lifestyles and physical fitness of Portuguese urban and rural youth is limited (Coelho e Silva *et al.*, 2003). PA occurs in social contexts that have specific demands and constraints such as opportunities for walking, access to playgrounds, proximity to shopping centres, and so on. Changes in parental work habits, television viewing, availability of video games, and other culturally-related factors in the environment have been also been indicated as contributing to increased opportunities for sedentary behaviours (Moreno et al., 2001). The effect of urbanization may also interact with rearing styles, for example, mothers with higher levels of education are more likely to engage in health-promoting behaviour (Sherar *et al.*, 2009).

The purpose of this study was to compare PA, physical inactivity, time spent in screen-related sedentary activities, and CRF in rural and urban adolescents in the Portuguese Midlands. Although the proposed topic is interesting in its own right, it is presently relevant given the observation that youth from southern European countries, including Portugal, have a high prevalence of overweight and obesity (Padez *et al.* 2004).

METHODS

Sample

The study was part of a cross-sectional school-based survey of the prevalence of overweight/obesity in Portugal (Sardinha *et al*. 2010). All administrative regions of mainland Portugal (Alentejo, Allgarve, Midlands, Lisbon and North) were surveyed. The population was selected by proportionate stratified random sampling taking into account the location (region) and the number of students by age (10-18 years) and gender in each school. Schools were randomly selected within each region until the established number of subjects by region was attained. Details described elsewhere (Sardinha *et al*. 2010). The present study was a part of the *Midlands Adolescent Lifestyle Study* (MALS). The sample included 362 adolescents 13-16 years of age resident in the Portuguese Midlands (165 males, 197 females). The youth were drawn from seven secondary schools, grades 7 through 9, and had valid accelerometer-based data.

The Portuguese Midlands include five districts (Aveiro: 752,867 inhabitants, km²; Leiria: 477,967 inhabitants, km²; Viseu: 394,844 inhabitants, km²; Castelo Branco: 208,069 inhabitants, km²; Guarda: 173,831 inhabitants, km²). The city of Coimbra is the primary urban centre, with a population of 148.443 in 319 km². Coimbra is located approximately midway between the two largest urban regions in the country, Lisbon and Porto, with populations of 2.7 and 1.7 million, respectively.

The project was registered at the *Portuguese Commission for Data Protection* [Process #3132006] and approved by the *Scientific Committee* of the *University of Coimbra*. Informed written assent was obtained from participants and informed consent was obtained from parents or guardians.

Anthropometry

Height and weight were measured at school in the morning using a portable stadiometer (Harpenden model 98.603, Holtain Ltd, Crosswell, UK) and a portable scale (Seca model 770, Hanover, MD, USA) to the nearest 0.1 cm and 0.1 kg, respectively, with participants in t-shirt and shorts, and without shoes. The body mass index (BMI, kg/m^2) was calculated. Students were classified into two weight status groups, normal weight vs. overweight/obese, using the age- and sex-specific BMI cut-offs of the International Obesity Task Force (Cole *et al*. 2000).

Physical activity and inactivity

The *ActiGraph GT1M* accelerometer (ActiGraph™, LLC, Fort Walton Beach, FL, USA) was used for direct assessment of PA and sedentary behaviour. The small uniaxial accelerometer (3.8 cm x 3.7 cm x 1.8 cm) and light (27g) detects vertical accelerations ranging in magnitude from 0.05 to 2.00g with a frequency of response of 0.25-2.50 Hz that permits normal human motion assessment. The filtered acceleration signal is digitized and the magnitude is summed over a user-specified period of time (epoch interval). At the end of each epoch, the summed value is stored in the memory. The device was validated in laboratory and under free-living conditions with children and adolescents (Freedson *et al*. 2005). Participants wore the accelerometer over the hip for five consecutive days (Thursday through Monday). Data were registered as counts per minute, consistent with previous studies in Europe (Riddoch *et al*. 2004) and the U.S. (Troiano *et al*. 2008). The output was expressed as average number of minutes spent at different intensities of PA [e.g. time spent inactive, light PA, and moderate-to-vigorous physical activity (MVPA)]. Students were instructed to remove the monitor while showering and performing aquatic activities. The data were electronically downloaded using the *ActiLife software*. The *MAHUffe program* was used to reduce the data into a file containing minute-by-minute movement counts for each subject. Participants who did not have 10 hours of valid measured data for each of the five days were excluded from subsequent analyses (Riddoch *et al*. 2004). The criterion for non-wear was defined as 20 minutes of consecutive zeros, allowing for 2 minutes of interruptions.

Data for 362 youth (74% of the initial sample of 492) met the criteria for inclusion and were used for all subsequent analyses, i.e., were compliant for wearing the accelerometer. The accelerometry records of 130 students (26%) failed to achieve 10 hours of registered time in each of the 5 measured days. Of these students, 12 did not achieve at least 3 completed days, 41 did not have 4 complete days and the remaining 77 did not reach 5 completed days necessary for inclusion in subsequent analyses. Corresponding compliance in previous research was 71% among European adolescents (Bringolf-Isler *et al*. 2009) and 62% to 75% among US youth (Anderson et al. 2005; Sallis et al. 1998). Distributions of included and excluded youth did not differ by sex [$\chi_{(1)}^2$=1.22; p=0.27], age [$\chi_{(1)}^2$=2.88 p=0.09], and weight status [$\chi_{(1)}^2$=0.48 p=0.49].

Inactivity was estimated using accelerometer specific cut-points established against continuous measurement of energy expenditure (EE) by respiration calorimetry in a sample of children and adolescents 6 to 16 years of age (Puyau *et al.* 2002). The threshold of inactivity was 800 counts.min^{-1}. Intensity-levels of PA were determined using an age-specific regression equation (Trost *et al*. 2002). The inclusion criteria and cut-points were previously used in pediatric epidemiological studies (Riddoch *et al*. 2004; Troiano *et al*. 2008).

Cardiorespiratory Fitness (CRF)

CRF was assessed by the Progressive Aerobic Cardiovascular Endurance Run test (PACER), a multistage 20-m endurance shuttle run test (Leger *et al*. 1988). The PACER was scored as the number of "laps" completed at volitional exhaustion. Participants were required to run between 2 lines 20 m apart using a cadence dictated by a CD emitting audible signals at prescribed intervals. Initial speed was set at 8.5 km/h for the first minute and then was increased 0.5 km/h each subsequent minute. When the subject could no longer keep the pace by reaching the line at the sound of the tone, the test was terminated (at the second fault) and the number of laps completed was recorded. The output was expressed as average distance (meters) completed by participants. The 20-m shuttle-run test is accepted as a valid and reliable estimate of VO_{2max} and in turn CRF in children and adolescents (Leger *et al*. 1988; van Mechelen *et al*. 1986). The test is also frequently incorporated into physical education (PE) curricula to track CRF levels among youth. The test protocol was explained in full before the start and all testing was done in PE classes under dry weather conditions. Replicate PACER tests were done on 23 students, one week apart. The technical error and reliability coefficient were 2.6 "laps" (51.6 m) and 0.97, respectively.

Sedentary behaviours

Screen time, including TV viewing, computer use and video games, was the indicator of sedentary behaviour consistent with other studies (Tremblay 2010). The amount of time spent on screen activities was determined from an activity diary (Bouchard *et al*. 1983; Machado Rodrigues *et al*. 2010) and expressed as min/day. Reliability and validity of the instrument have been reported (Machado-Rodrigues *et al*., 2010). Respondents were grouped as having ≤2 h/day and >2 h/day screen time according to guidelines suggested by the *American Academy of Pediatrics* (American Academy of Pediatrics 2001).

Area of Residence

Place of residence for each participant was self-reported in a socio-demographic questionnaire (Coelho e Silva et al., 2003). The place of residence for each individual subsequently classified as urban or rural according criteria of the Portuguese Statistical System (Monteiro 2000). Urban areas were defined as a city with more than 500 inhabitants/Km^2 or more than 50,000 inhabitants. Rural areas were defined as villages with no more than100 inhabitants/Km^2 or with total population under 2000 people.

Rural and urban youth varied in type of living unit and educational level of parents. Overall, 84% and 16% of rural adolescents lived, respectively, in a house or flat/apartment, compared to 38% and 62%, respectively, of urban adolescents. Only 9% of fathers of rural youth had a college or university degree (highest educational level) while 26% completed 9 compulsory years of schooling (lowest educational level); among mothers of rural youth, 12% and 25%, respectively, had the highest and lowest educational levels.. Corresponding numbers for parents of urban adolescents presented a marked contrast: 61% and 65% of mothers had attained the highest educational level, while only 7% of fathers and 5% of mothers had the lowest educational level.

Statistical Analysis

Chronological age was calculated as the difference between date of birth and date on which height and weight were measured. Since age and gender are indicated as factors affecting PA, CRF and weight status among adolescents (Malina *et al*., 2004), analyses were done separately for males and females and for younger and older age groups (13-14 and 15-16 years). Descriptive statistics included means and standard deviations for intensity of PA, time spent physically inactive (sedentary), CRF, and screen time (sedentary behaviour). A series of sex-specific one-way analyses of variance (ANOVA) were done to test age differences in each variable. Several differences were observed between younger and older age groups, primarily for MVPA in both both genders and time spent physically inactive in females, analyses of co-variance (controlling for chronological age) were performed to test urban-rural contrasts in cardiorespiratory fitness, physical activity and time spent physically inactive by males and females separately. Since there was no significant effect of parental education on the dependent variables, parental education was not included as covariate in the model testing the effect of area of residence. All ANOVAs and ANCOVAs were followed-up with Bonferroni-corrected *post hoc* tests. SPSS 15.0 (SPSS Inc., Chicago, Illinois, USA) was used for all analyses. Level of significance was set at $p<.05$. Partial eta squared was used to evaluate the magnitude of differences between groups; F values of 0.10, 0.25, and 0.40 were interpreted as small, medium and large effects, respectively (Cohen 1998). Expressed as partial eta squared, values of 0.01, 0.06, and 0.14 were, respectively, considered small, moderate and large effects.

RESULTS

Descriptive statistics for chronological age, body size, sedentary behaviour, time being inactive based on accelerometry (physical inactivity), and PA by intensity level are summarized by sex and age in Table 1. Older boys (15-16 years) were, on average, significantly heavier and taller, presented higher BMIs and had higher CRF compared to younger boys (13-14 years). The latter, however, spent significantly more minutes in MVPA on week days, weekend days, and across all monitored days (week days and weekend days combined), and spent less time in light activities on week days, weekend days and across all days than boys 15-16 years. The magnitude of the significant effects was at best moderate, except for MVPA (moderate to large).

[Table 1 about here]

Older girls (15-16 years) were heavier and taller than younger peers (13-14 years), but BMI and CRF did not differ between age groups. Younger girls were more physically active in MVPA on week days, weekend days and across all days than older girls who spent more time being physically inactive on total days than younger girls (differences on week days and weekend days were marginally significant).

Descriptive statistics by area of residence are summarized in Table 2. Urban and rural boys did not differ in age, height, weight and BMI. Urban boys spent significantly less time being physically inactive than rural boys on week days and across all days, but the groups did not differ on weekend days. Urban boys also spent significantly less time in sedentary activities (screen time) than rural peers on week days and across all days. Rural boys spent significantly more time in light physical activities than urban boys on week days, while urban boys spent significantly more time in MVPA than rural boys over the weekend. Rural boys demonstrated significantly higher levels of CRF than urban peers. The magnitude of the significant effects was moderate at best.

[Table 2 about here]

Urban and rural girls did not differ in age, height, weight and BMI. Urban girls spent significantly less time in sedentary activities (screen time) than rural girls on week days, and spent significantly less time in light physical activities than rural girls on week days, weekend days, and all days. Urban girls also spent significantly less time in MVPA on week days and across all days. Rural females had significantly higher levels of CRF than urban peers (Table 2). The magnitude of the significant effects was at best moderate.

DISCUSSION

Time spent being physically inactive and involved in PA at different intensities based on accelerometry, in sedentary behaviour (screen activities), and level of CRF were considered among adolescents from urban and rural communities in the Portuguese Midlands. Rural boys and girls had higher levels of CRF than urban peers. Similar results were previously noted among youth in Spain (Chillon *et al*. 2011) and Oman (Albarwani *et al*. 2009). Although rural boys have had a higher level of CRF, they tended to be less active in MVPA than urban boys, particularly on the weekend (urban = 68 $min.day^{-1}$; rural = 54 $min.day^{-1}$). The findings were consistent with previous studies in suggesting that rural adolescents were less physically active than urban peers in U.S. (Liu *et al*. 2008; Lutfiyya *et al*. 2007) and Iceland (Kristjansdottir and Vilhjalmsson 2001).

The difference in MVPA between young (13-14 years) and older (15-16 years) adolescents of both sexes was consistent with the decline generally observed with age as youth transition through adolescence (van Mechelen *et al*. 2000). The results were also consistent with expected changes in the nature of PA during adolescence. PA tends to become less structured and less intense in both sexes across adolescence, while girls more so than boys tend to focus their interests on social activities (Coelho e Silva *et al*. 2003). On the other hand, CRF was greater in older compared to younger boys, but did not differ between the age groups of girls. The trends were also consistent with variation in aerobic fitness during adolescence (Malina *et al*. 2004).

Geographic context and cardiorespiratory fitness

Interactions among several environmental factors may underlie why rural Portuguese youth were more likely to be classified as physically fit on CRF (PACER test). A key factor may be school physical education programs, but the quality of the Portuguese curriculum based largely on sport education and practice is the same for rural and urban schools (Coelho-e-Silva *et al*., 2003). Since time spent outdoors is positively related to physical activity in youth (Sallis *et al*. 2000), perceived safety of the environment may be a factor especially in urban settings. Portuguese female adolescents living in high-crime neighbourhoods, which are more frequent in urban communities, were less active outdoors (Mota *et al*. 2007). It is possible that rural adolescents resided in safer neighbourhoods and were more likely to be physically active, which increased the likelihood of being classified as aerobically fit.

Transport to school may be an additional factor that moderates the relationship between CRF and area of residence. In an earlier study of adolescents from the Portuguese Midlands, a greater percentage of urban than rural youth walked to school, while a greater percentage of rural than urban youth used public transport (Coelho e Silva *et al*. 2003). It is not clear, however, whether mode of transport significantly affects the CRF of youth.

Urban-rural contrast of sedentary behaviour

Urban boys spent less time being physically inactive than rural boys, while rural adolescents of both sexes spent more time on sedentary activities (screen time) than urban youth. These findings contrast data from the U.S. suggesting that urban youth of both sexes were more sedentary than rural youth (Liu *et al*. 2008; Springer *et al*. 2006). The U.S. studies used electronic media as a proxy for sedentary behaviours. Of relevance, TV viewing and computer use were not the only form of sedentary behaviour in adolescents, who also spent substantial amounts of time sitting in school classes, riding in cars, eating, socialising, reading and studying (Olds *et al*. 2010). School activities contributed 42% of non-screen sedentary time among Australian adolescents in contrast to socialising, 19%, self-care (mainly eating), 16%, and passive transport, 15% (Olds *et al*. 2010). Screen time was negatively correlated with non-screen sedentary time (r=-0.58) and moderate correlated with total sedentary time (r=0.53); screen time was thus only a moderately effective surrogate for total sedentary time. The Australian youth spent, on average, 345 minutes per day in non-screen sedentary time (60% of total sedentary time). Percentages of time in non-screen sedentary activities were

71% and 75% for rural and urban males, and 76% and 80% for rural and urban females, respectively.

Active lifestyle in different geographic communities

Social and cultural differences between rural and urban areas are reasonably well documented, but vary within and between countries (Barreto 2000; Reyes *et al*. 2003). Low income urban neighbourhoods generally had a negative influence on health, academic achievement and behavioural outcomes (Cicognani *et al*. 2008). Young people living in neighbourhoods with good access to shops tended to have healthier diets and were less likely to be overweight (Veugelers *et al*. 2008). Economic status of an area may influence access to recreational facilities and in turn to sports and other active leisure behaviours. Open public spaces in less deprived neighbourhoods tended to have better environmental quality compared to more deprived neighbourhoods; however, the former had fewer activities and safety features (Badland *et al*. 2010). This was especially relevant as participation in organized sport is related to MVPA, and PA is often identified as sport among youth of both sexes (Malina 2008). Among American youth, organized sports contributed to 23% of time in MVPA in boys 6-12 years (Wickel and Eisenmann 2007) and to about 65% of the daily EE in MVPA in boys 12-14 years (Katzmarzyk and Malina 1998). In the present study, differences in MVPA between rural and urban groups were only apparent for boys on weekends. Urban boys were more active than rural boys, and it may be suggested that sport participation was a more likely feature among urban boys.

Parental education may influence physical activity among the urban boys since parents serve as important behavioural role models from early childhood through to the teen years (Sherar *et al*. 2009). Urban adolescents of both sexes were from more highly educated families and also had higher levels of PA, particularly among males. The literature on the issue of parental education, however, is somewhat inconclusive. Some studies showed a positive relationship between maternal education and youth PA (Butcher et al. 2008; Gordon-Larsen et al. 2000; Hesketh et al. 2006; Lasheras et al. 2001), while others showed no relationship (Riddoch et al. 2007; Sallis et al. 2002). The equivocal nature of the findings may be attributed to variation in methods of assessing PA and parental education in different countries. Use of aggregated and self-reported protocols may not reflect the true and detailed variation in PA. Moreover, educational background of parents is often used as a proxy for socio-economic status (Gidlow et al. 2006). Future studies should address variables related to income and professional activity of parents as complementary criteria.

Moderate-to-vigorous physical activity

In contrast to males, urban adolescent girls spent significantly less time in MVPA than their rural counterparts. Indeed, the nature of PA required among rural adolescents and social and familial influences might explain the larger amount of time in MVPA by rural female girls the present study. Rural girls were more likely to be involved in domestic activities and at times in agricultural activities that required more energy expenditure, while urban girls tended to focus interests on less physically active social activities such as sitting and talking with friends (Coelho e Silva *et al*. 2003). It was difficult to compare results of the present study to urban-rural contrasts in other countries as the data were not strictly comparable. Criteria for urban and rural residence varied within and among countries. For example, urban Icelandic adolescents walked or cycled to school for about three times the distance of rural peers (Kristjansdottir and Vilhjalmsson 2001). Rural areas in the U.S. tended to have extensive school bussing programs, which was consistent with the observation that U.S. urban youth tended to more likely meet recommended PA levels (Lutfiyya *et al*. 2007). Other studies (Ismailov and Leatherdale 2010; Liu *et al*. 2008; Lutfiyya *et al*. 2007; Moreno *et al*. 2001) have reported urban-rural differences in the BMI with rural adolescents more often having an elevated BMI compared to urban youth. Such differences were not evident among rural and urban adolescents in the Portuguese Midlands.

The observation that urban adolescents had higher PA counts but lower levels of CRF than rural youth (Table 2) may appear paradoxical given the intuitively implied relationship between PA and CRF. Although more physically active adolescents tended to have higher levels of aerobic fitness, correlations between habitual PA and both maximal and submaximal indicators of CRF tended to be low to moderate in magnitude (Strong *et al.* 2005). Moreover, results of multivariate analyses indicated that measures of PA accounted for relatively small percentages of variance in different tests of CRF, usually less than 20%, in samples of adolescents (Huang and Malina 2002; Katzmarzyk *et al.* 1999). This should come as no surprise since PA behaviours are multidimensional and probably change from day-to-day during adolescence, whereas CRF is largely a physiological or functional attribute. In addition, laboratory and field measures of CRF are related but vary in sensitivity as indicators of CRF. Maximal (peak VO2) and submaximal (PWC170) aerobic performances also have adolescent growth spurts which vary in timing among individuals of both sexes and also relative to growth spurts in height, weight and performance (Malina *et al*. 2004). The preceding must be set in the context of genotype. Allowing for sample characteristics and analytical strategies, indicators of aerobic performance show moderate to high heritabilities (Beunen *et al*. 2011; Bouchard *et al*. 1997).

Limitations of the study

The present study has several limitations that should be recognized. The study is cross-sectional so that cause-effect relationships cannot be assumed. Observations are limited to a sample of Portuguese youth 13 to 16 years of age living in Midlands region of the country. Generalization of the results to other samples of rural and urban adolescents should thus be made with caution. Although accelerometers provide an objective and reasonably accurate measure of PA, they probably do not capture all dimensions of PA (sports/activities in the water or where the accelerometer may present a risk). On the other hand, the present study adopted an epoch of 60 seconds which tends to underestimate moderate, vigorous and very vigorous physical activities, especially in children (Nilsson *et al*. 2002; Rowlands *et al*. 2006; Stone *et al*. 2009). Time spent in activities of different intensities was not considered in the present study. In addition, the cut-offs for intensity categories of PA are also somewhat arbitrary because they depend on the type of activities performed when establishing the relationship between activity counts and energy expenditure and also on characteristics of the sample considered. Therefore, results should also be interpreted with these limitations in mind. Accelerometry is, to some extent, a work-in-progress, and as improved calibration of accelerometer data becomes available, modifications may be required. Finally, parental education was used as a proxy for socio-economic status. Future research should assess other parent-related variables such as income, type of employment, leisure activities, and so on.

Unique aspects of urban and rural environments that may impact PA, physical inactivity and/or CRF among children and adolescents should be identified and systematically studied. Features of the built environment in urban and rural Portuguese communities were not considered. Research using specific variables related to the built environment is recommended to enhance the understanding of how factors such as distance from home to school, availability of PA facilities, perception of the area of residence, and perhaps attitudes towards PA and CRF, among others, relate to urban-rural contrasts. Such observations may serve to better inform PA, recreational and educational interventions.

CONCLUSION

Area of residence was related to PA, physical inactivity, time in sedentary behaviour (screen time) and CRF among rural and urban Portuguese youth. Although the results suggested a potential impact of socio-geographic factors related to area of residence on PA, physical inactivity (accelerometry), sedentary behaviour (screen time) and CRF, they also highlighted a need for a better understanding of the details daily life among adolescents resident in urban and rural settings. Accelerometry, though valuable, does not capture contexts of PA and factors underlying the contexts. Nevertheless, interventions seeking to enhance health and active lifestyles in Portuguese youth should consider the potential impact of socio-geographic factors, and should examine in more details specific aspects of rural and urban living than may influence PA, inactivity, sedentary behaviour and CRF.

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REFERENCES

Albarwani S, Al-Hashmi K, Al-Abri M, Jaju D, and Hassan MO. 2009. Effects of overweight and leisure-time activities on aerobic fitness in urban and rural adolescents. Metab Syndr Relat Disord 7(4):369-374.
American Academy of Pediatrics A. 2001. Children, adolescents, and television. Pediatrics 107:423-426.
Anderson CB, Hagstromer M, and Yngve A. 2005. Validation of the PDPAR as an adolescent diary: effect of accelerometer cut points. Med Sci Sports Exerc 37(7):1224-1230.
Badland HM, Keam R, Witten K, and Kearns R. 2010. Examining public open spaces by neighborhood-level walkability and deprivation. J Phys Act Health 7(6):818-824.
Barreto A. 2000. A Situação Social em Portugal, 1960–1999: Lisboa: Universidade de Lisboa.

Beunen G, Peeters MW, and Malina RM. 2011. Twin studies in sport performance. In: Bouchard C, and Hoffman EP, editors. Genetic and Molecular Aspects of Sport Performance. West Sussex, UK: Blackwell Publishing, Ltd, John Wiley and Sons. p 101-109.

Bouchard C, Malina RM, and Perusse L. 1997. Genetics of Fitness and Physical Performance. Champaign, IL: Human Kinetics.

Bouchard C, Tremblay A, Leblanc C, Lortie G, Savard R, and Theriault G. 1983. A method to assess energy expenditure in children and adults. Am J Clin Nutr 37(3):461-467.

Bringolf-Isler B, Grize L, Mader U, Ruch N, Sennhauser FH, and Braun-Fahrlander C. 2009. Assessment of intensity, prevalence and duration of everyday activities in Swiss school children: a cross-sectional analysis of accelerometer and diary data. Int J Behav Nutr Phys Act 6:50.

Butcher K, Sallis JF, Mayer JA, and Woodruff S. 2008. Correlates of physical activity guideline compliance for adolescents in 100 U.S. Cities. J Adolesc Health 42(4):360-368.

Chillon P, Ortega FB, Ferrando JA, and Casajus JA. 2011. Physical fitness in rural and urban children and adolescents from Spain. J Sci Med Sport.

Cicognani E, Albanesi C, and Zani B. 2008. The impact of residential context on Adolescent´s subjective well being. Journal of Community & Applied Social Psychology 18:558-575.

Coelho e Silva M, Sobral F, and Malina RM. 2003. Determinância sociogeográfica da prática desportiva na adolescência: Faculdade de Ciências do Desporto e Educação Física, Universidade de Coimbra.

Cohen J. 1998. Statistical power analysis for the behavioral sciences. New York: Academic Press.

Cole TJ, Bellizzi MC, Flegal KM, and Dietz WH. 2000. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 320(7244):1240-1243.

Ezzati M, Utzinger J, Cairncross S, Cohen AJ, and Singer BH. 2005. Environmental risks in the developing world: exposure indicators for evaluating interventions, programmes, and policies. J Epidemiol Community Health 59(1):15-22.

Freedson P, Pober D, and Janz KF. 2005. Calibration of accelerometer output for children. Med Sci Sports Exerc 37(11 Suppl):S523-530.

Gidlow C, Johnston LH, Crone D, Ellis N, and James D. 2006. A systematic review of the relationship between socio-economic position and physical activity. Health Education Journal 65:338-367.

Gordon-Larsen P, McMurray RG, and Popkin BM. 2000. Determinants of adolescent physical activity and inactivity patterns. Pediatrics 105(6):E83.

Hesketh K, Crawford D, and Salmon J. 2006. Children's television viewing and objectively measured physical activity: associations with family circumstance. Int J Behav Nutr Phys Act 3:36.

Huang Y, and Malina RM. 1996. Physical activity and correlates of estimated energy expenditure in Taiwanese adolescents 12-14 years of age. American Journal of Human Biology 8:225-236.

Huang YC, and Malina RM. 2002. Physical activity and health-related physical fitness in Taiwanese adolescents. J Physiol Anthropol Appl Human Sci 21(1):11-19.

Ismailov RM, and Leatherdale ST. 2010. Rural-urban differences in overweight and obesity among a large sample of adolescents in Ontario. Int J Pediatr Obes.

Katzmarzyk PT, and Malina RM. 1998. Contribution of organized sports participation to estimated daily energy expenditure in youth. Pediatric Exercise Science 10:378-386.

Katzmarzyk PT, Malina RM, and Bouchard C. 1999. Physical activity, physical fitness, and coronary heart disease risk factors in youth: the Quebec Family Study. Prev Med 29(6 Pt 1):555-562.

Kristjansdottir G, and Vilhjalmsson R. 2001. Sociodemographic differences in patterns of sedentary and physically active behavior in older children and adolescents. Acta Paediatr 90(4):429-435.

Lasheras L, Aznar S, Merino B, and Lopez EG. 2001. Factors associated with physical activity among Spanish youth through the National Health Survey. Prev Med 32(6):455-464.

Leger LA, Mercier D, Gadoury C, and Lambert J. 1988. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci 6(2):93-101.

Liu J, Bennett KJ, Harun N, and Probst JC. 2008. Urban-rural differences in overweight status and physical inactivity among US children aged 10-17 years. J Rural Health 24(4):407-415.

Lutfiyya MN, Lipsky MS, Wisdom-Behounek J, and Inpanbutr-Martinkus M. 2007. Is rural residency a risk factor for overweight and obesity for U.S. children? Obesity (Silver Spring) 15(9):2348-2356.

Machado Rodrigues AM, Coelho e Silva MJ, Figueiredo AJ, Mota J, Cumming SP, Eisenmann JC, and Malina RM. 2010. Concurrent validation of estimated activity energy expenditure using a 3-day diary and accelerometry in adolescents. Scand J Med Sci Sports (in press).

Malina RM. 2008. Biocultural factors in developing physical activity levels. . In: Smith AL, and Biddle SJH, editors. Youth Physical Activity and Sedentary Behavior: Challenges and Solutions. Champaign, IL: Human Kinetics. p 141-166.

Malina RM, Bouchard C, and Bar-Or O. 2004. Growth, Maturation, and Physical Activity: Human Kinetics: Champaigh, IL.

Monteiro JL. 2000. Caracterização dos espaços urbanos urbanos na região de Lisboa e Vale do Tejo: o contributo da análise descriminante. Revista de Estudos Regionais - Instituto Nacional de Estatística 2º semestre 2000(1).

Moreno LA, Sarria A, Fleta J, Rodriguez G, Gonzalez JM, and Bueno M. 2001. Sociodemographic factors and trends on overweight prevalence in children and adolescents in Aragon (Spain) from 1985 to 1995. J Clin Epidemiol 54(9):921-927.

Mota J, Gomes H, Almeida M, Ribeiro JC, and Santos MP. 2007. Leisure time physical activity, screen time, social background, and environmental variables in adolescents. Pediatr Exerc Sci 19(3):279-290.

Nilsson A, Ekelund U, Yngve A, and Sjostrom M. 2002. Assessing physical activity among children with accelerometers using different time sampling intervals and placements. Pediatric Exercise Science 14(87-96).

Olds TS, Maher CA, Ridley K, and Kittel DM. 2010. Descriptive epidemiology of screen and non-screen sedentary time in adolescents: a cross sectional study. The international journal of behavioral nutrition and physical activity 7:92.

Padez C, Fernandes T, Mourao I, Moreira P, and Rosado V. 2004. Prevalence of overweight and obesity in 7-9-year-old Portuguese children: trends in body mass index from 1970-2002. Am J Hum Biol 16(6):670-678.

Puyau MR, Adolph AL, Vohra FA, and Butte NF. 2002. Validation and calibration of physical activity monitors in children. Obes Res 10(3):150-157.

Reyes ME, Tan SK, and Malina RM. 2003. Urban-rural contrasts in the growth status of school children in Oaxaca, Mexico. Ann Hum Biol 30(6):693-713.

Riddoch CJ, Bo Andersen L, Wedderkopp N, Harro M, Klasson-Heggebo L, Sardinha LB, Cooper AR, and Ekelund U. 2004. Physical activity levels and patterns of 9- and 15-yr-old European children. Med Sci Sports Exerc 36(1):86-92.

Riddoch CJ, Mattocks C, Deere K, Saunders J, Kirkby J, Tilling K, Leary SD, Blair SN, and Ness AR. 2007. Objective measurement of levels and patterns of physical activity. Arch Dis Child 92(11):963-969.

Rowlands AV, Powell SM, Humphries R, and Eston RG. 2006. The effect of accelerometer epoch on physical activity output measures. J Exerc Sci Fit 4(1):52-58.

Sallis JF, Kraft K, and Linton LS. 2002. How the environment shapes physical activity: a transdisciplinary research agenda. Am J Prev Med 22(3):208.

Sallis JF, McKenzie T, Elder J, Hoy P, Galati T, Berry C, Zive M, and Nader PR. 1998. Sex and ethnic differences in children's physical activity: Discrepancies between self-report and objective measures. *Pediatric Exercise Science* 10:277-284.

Sallis JF, Prochaska JJ, and Taylor WC. 2000. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc 32(5):963-975.

Sardinha LB, Santos R, Vale S, Silva AM, Ferreira JP, Raimundo AM, Moreira H, Baptista F, and Mota J. 2010. Prevalence of overweight and obesity among Portuguese youth: A study in a representative sample of 10-18-year-old children and adolescents. International Journal of Pediatric Obesity:1-5.

Seabra A. 2004. A influência de determinantes demográfico-biológicas e sócio-culturais nos níveis de actividade física de crianças e jovens (Master Thesis). Porto: Faculdade de Medicina, Instituto de Ciências Biomédicas de Abel Salazar - Universidade do Porto.

Sherar LB, Muhajarine N, Esliger DW, and Baxter-Jones AD. 2009. The relationship between girls' (8-14 years) physical activity and maternal education. Ann Hum Biol 36(5):573-583.

Sjolie AN, and Thuen F. 2002. School journeys and leisure activities in rural and urban adolescents in Norway. Health Promot Int 17(1):21-30.

Springer AE, Hoelscher DM, and Kelder SH. 2006. Prevalence of Physical Activity and Sedentary Behaviors in US High School Students by Metropolitan Status and Geographic Region. *Pediatric Exercise Science*(3):365-380.

Stone MR, Rowlands AV, and Eston RG. 2009. The use of high-frequency accelerometry monitoring to assess and interpret children's activity patterns. In: T. Jurimae NA, J. Jurimae, editor. Children and exercise XXIV : the proceedings of the 24th Pediatric Work Physiology Meeting. London: Routledge. p 150-153.

Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, Hergenroeder AC, Must A, Nixon PA, Pivarnik JM et al. . 2005. Evidence based physical activity for school-age youth. J Pediatr 146(6):732-737.

Taks M, Renson R, Beunen G, Claessens A, Colla M, Lefevre J, Ostyn M, Schueremans C, Simons J, Van Gerven D et al. . 1991. Sociogeographic variation in the physical fitness of a cross-sectional sample of Flemish girls 13 to 18 years of age. American Journal of Human Biology 3(5):503–513.

Tremblay M. 2010. Assessing the level of sedentarism. In: Bouchard C, and Katzmarzyk PT, editors. Physical activity and obesity. Champaign, IL: Human Kinetics. p 13-17.

Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, and McDowell M. 2008. Physical activity in the United States measured by accelerometer. Med Sci Sports Exerc 40(1):181-188.

Trost SG, Pate RR, Sallis JF, Freedson PS, Taylor WC, Dowda M, and Sirard J. 2002. Age and gender differences in objectively measured physical activity in youth. Med Sci Sports Exerc 34(2):350-355.

van Mechelen W, Hlobil H, and Kemper HC. 1986. Validation of two running tests as estimates of maximal aerobic power in children. Eur J Appl Physiol Occup Physiol 55(5):503-506.

van Mechelen W, Twisk JW, Post GB, Snel J, and Kemper HC. 2000. Physical activity of young people: the Amsterdam Longitudinal Growth and Health Study. Med Sci Sports Exerc 32(9):1610-1616.

Veugelers P, Sithole F, Zhang S, and Muhajarine N. 2008. Neighborhood characteristics in relation to diet, physical activity and overweight of Canadian children. Int J Pediatr Obes 3(3):152-159.

Wickel EE, and Eisenmann JC. 2007. Contribution of youth sport to total daily physical activity among 6- to 12-yr-old boys. Med Sci Sports Exerc 39(9):1493-1500.

Xu F, Yin XM, and Tong SL. 2007. Association between excess bodyweight and intake of red meat and vegetables among urban and rural adult Chinese in Nanjing, China. Asia Pac J Public Health 19(3):3-9.

Table 1. Descriptive statistics and results of ANOVAs testing the effect of age group on body size, sedentary behaviour, physical activity, inactivity, and aerobic endurance separately for males (left) and females (right).

	Males (n=165)					Females (n=197)				
	13-14 (n=100)	15-16 (n=65)	F	p	η^2	13-14 (n=115)	15-16 (n=82)	F	p	η^2
Chronological age, years	13.5±0.6	15.3±0.6	344.30	0.00	0.68	13.5±0.6	15.2±0.5	454.33	0.00	0.70
Height, cm	160.7±9.0	170.6±7.4	55.54	0.00	0.24	157.5±6.2	159.4±5.8	4.62	0.03	0.02
Weight, Kg	50.6±10.8	62.6±10.1	51.89	0.00	0.25	52.0±9.5	54.6±9.3	3.78	0.05	0.02
BMI, kg . m^{-2}	19.44±3.01	21.51±3.28	17.45	0.00	0.10	20.90±3.42	21.47±3.24	1.37	0.24	0.01
SB: week, hours/day	2.57±1.52	2.79±1.77	0.72	0.40	0.01	2.27±1.29	2.51±1.52	1.37	0.24	0.01
SB: week-end, hours/day	4.87±3.30	3.94±3.46	2.99	0.09	0.02	3.36±2.35	3.41±2.72	0.02	0.88	0.00
SB: all days, hours/day	3.34±1.79	3.17±2.06	0.29	0.59	0.01	2.63±1.39	2.81±1.67	0.64	0.43	0.00
Inactivity: week, min/day	710.6±65.2	727.9±61.0	2.90	0.09	0.02	741.4±64.9	751.4±52.8	1.34	0.25	0.01
Inactivity: weekend, min/day	667.0±87.0	659.7±79.23	0.30	0.59	0.00	652.7±71.6	696.8±81.8	16.11	0.00	0.08
Inactivity: all days, min/day	693.0±58.7	700.5±57.9	0.65	0.42	0.01	705.8±53.8	729.4±54.4	9.18	0.00	0.05
Light PA: week, min/day	63.5±18.1	76.3±22.1	16.54	0.00	0.09	64.7±23.6	71.5±21.6	4.25	0.04	0.02
Light PA: weekend, min/day	61.5±28.3	72.8±29.8	5.97	0.02	0.04	62.3±28.8	60.5±25.6	0.20	0.66	0.00
Light PA: all days, min/day	62.6±19.1	74.8±21.5	14.59	0.00	0.08	63.7±24.1	67.0±20.3	1.04	0.31	0.01
MVPA: week, min/day	106.3±37.4	73.7±31.1	34.10	0.00	0.17	80.1±28.4	64.6±29.1	14.08	0.00	0.07
MVPA: weekend, min/day	63.5±39.1	49.4±31.7	5.90	0.02	0.04	48.8±30.9	35.2±26.9	10.27	0.00	0.05
MVPA: all days, min/day	89.1±32.2	63.9±25.7	28.09	0.00	0.15	67.5±26.3	52.7±24.9	15.82	0.00	0.08
Aerobic endurance, m	1253±411	1464±486	9.03	0.00	0.05	743±286	805±311	2.05	0.15	0.05

BMI (Body Mass Index);); PA (Physical Activity); SB (sedentary behaviour); MVPA (Moderate-to-Vigorous Physical Activity).

Table 2. Descriptive statistics and results of ANCOVAs (chronological age as co-variable) testing the effect of degree of urbanization on body size, sedentary behaviour, physical activity, inactivity, and aerobic endurance (left, boys; right, girls).

	Males (n=165)					Females (n=197)				
	Rural (n=116)	Urban (n=49)	F	p	η^2	Rural (n=141)	Urban (n=56)	F	p	η^2
Height, cm	164.7±9.4	164.5±10.5	0.276	0.60	0.01	158.1±6.4	158.7±5.01	1.299	.26	0.00
Weight, Kg	56.1±12.0	53.5±12.0	0.937	0.34	0.01	53.4±10.0	52.2±7.9	0.205	.65	0.01
BMI, kg . m^{-2}	20.52±3.25	19.62±3.26	2.055	0.15	0.01	21.31±3.53	20.70±2.84	0.977	.32	0.01
SB: week, hours/day	2.83±1.61	2.26±1.60	4.151	0.04	0.03	2.51±1.39	2.01±1.34	4.033	.04	0.02
SB: week-end, hours/day	4.72±3.43	3.99±3.25	2.161	0.14	0.02	3.46±2.48	3.17±2.59	0.387	.54	0.00
SB: all days, hours/day	3.46±1.91	2.84±1.82	4.138	0.04	0.03	2.83±1.49	2.40±1.53	2.475	.12	0.01
Inactivity: week, min/day	724.7±61.1	700.2±67.8	4.653	0.03	0.03	743.3±60.5	751.2±59.6	1.411	.24	0.01
Inactivity: weekend, min/day	670.5±84.5	649.2±81.3	2.213	0.14	0.01	676.4±80.0	657.5±75.1	0.680	.41	0.00
Inactivity: all days, min/day	702.9±58.2	679.7±55.9	5.183	0.02	0.03	716.5±55.5	713.6±54.7	0.103	.75	0.00
Light PA: week, min/day	71.8±21.1	60.7±17.4	9.645	0.00	0.06	70.7±21.4	59.6±20.0	7.140	.01	0.04
Light PA: weekend, min/day	66.4±28.9	64.9±30.4	0.007	0.93	0.00	64.1±29.1	55.1±21.8	4.562	.03	0.02
Light PA: all days, min/day	69.6±21.3	62.3±19.1	3.532	0.06	0.02	68.0±22.6	57.7±21.0	7.083	.01	0.04
MVPA: week, min/day	91.6±36.7	97.9±42.4	0.377	0.54	0.01	76.0±29.2	67.7±30.0	9.000	.00	0.04
MVPA: weekend, min/day	53.6±35.9	68.2±37.7	4.785	0.03	0.03	43.0±28.1	43.5±34.4	0.480	.49	0.00
MVPA: all days, min/day	76.3±31.3	85.9±33.6	2.340	0.13	0.01	62.7±26.1	57.9±28.0	5.371	.02	0.03
Aerobic endurance, m	1407±455	1169±405	9.172	0.00	0.12	821±310	639±217	14.769	0.00	0.07

BMI (Body Mass Index);); PA (Physical Activity); SB (sedentary behaviour); MVPA (Moderate-to-Vigorous Physical Activity).