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RESEARCH ARTICLE

Waist Circumference and Objectively Measured Sedentary Behavior in Rural School Adolescents

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ABSTRACT

BACKGROUND: Research on relationships between lifestyle behaviors and adiposity in school youth is potentially important for identifying subgroups at risk. This study evaluates the associations between waist circumference (WC) and objective measures of sedentary behavior (SB) in a sample of rural school adolescents.

METHODS: The sample included 254 students (114 boys, 140 girls), 13-16 years of age, from rural regions of the Portuguese midlands. Height, weight, and WC were measured. Cardiorespiratory fitness (CRF) was assessed with the 20-m shuttle-run test. An uniaxial GT1M accelerometer was used to obtain 5 consecutive days of physically activity (PA) and SB. Multiple linear regression was used to test associations between WC and SB, adjusted for several potential confounders (age, sex, PA, CRF, parental education).

RESULTS: SB was not significantly associated with the WC, neither in the unadjusted model nor after adjustment for all potential confounders. In the final model, the unique significant predictor of the WC was cardiorespiratory fitness ($\beta = -0.82$; 95% confidence interval [CI], −1.02 to −0.62).

CONCLUSION: WC was not independently associated with SB time in rural school adolescents. Future research is claimed among rural adolescents in different geographic contexts to try to clarify recent findings of less studied communities.

Keywords: health promotion; physical activity; urbanization; accelerometer; youth.

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Transformation of communities, especially economic transformation, has important impacts on behavioral change in the resident populations.[1] Given the transformation of rural areas in many countries, interest in rural health issues and medicine has increased.[2] Residents in rural communities with relatively low population densities often have limited access to health services per se and to a variety of specialized health professionals compared with residents of urban centers.[3] Rural areas are also characterized by socioeconomic and educational and in some instances nutritional inequities that can impact the health of children and adolescents.[4,5]

Sedentary and physically active behaviors occur in contexts that differ between urban and rural settings. For example, access to playgrounds and proximity to shopping centers are limited in rural areas.[6] Both contexts are important behavioral domains

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with potential implications for physically active and sedentary behaviors (SB) among youth, respectively. They also interact with rearing styles and with social autonomy specifically among adolescents.[7,8]

Some research has indicated higher levels of SB among rural compared with urban youth in the United States.[9,10] The prevalence of overweight and obesity was also higher among rural compared with urban school youth in the United States,[9,10] Canada,[11] Portugal,[12] and Spain.[13] Note, however, criteria defining urban and rural areas probably vary among countries and perhaps in different regions of a country.

Although obesity has negative health consequences, abdominal obesity, and specifically intra-abdominal adiposity, is considered a major health risk. Intra-abdominal adipose tissue is related to the production and release of a variety of inflammatory agents.[14] Abdominal obesity is, to some extent, less investigated than general obesity among youth. Nevertheless, waist circumference (WC) is a good predictor of central obesity[15,16] and is consistently related to cardiometabolic risk factors in youth.[17,18]

Available research dealing with adolescent lifestyle by geographic context is rather limited. Urban-rural contrasts of physical activity (PA), SB, and adiposity have been reported for Spanish,[13] United States,[10] and Canadian[11] youth. Among Portuguese youth, data indicate higher PA in urban compared with rural youth which was due largely to greater sport participation in urban settings. In contrast, rural adolescents tended to have higher levels of SB than their urban peers.[12]

Given the negative implication of SB and adiposity in health,[19] it is important to address the relationship between abdominal obesity and SB in Portuguese youth, particularly in those students from rural communities where that information is quite limited. To the best of our knowledge, there have been no regional studies examining abdominal obesity in relation to objectively measured SB in the Portuguese Midlands where social inequalities relative to urban communities are apparent in health and educational resources.[4] Better understanding of the lifestyles of rural school youth may serve to inform the development of community, educational, and perhaps public health programs aimed at improving health status. In this context, this study evaluates relationships between objectively measured SB and WC in a sample of rural adolescents. It was hypothesized that SB would be positively related to WC in rural youth.

METHODS

Study Design and Sampling

The sample was part of a cross-sectional school-based survey of the prevalence of overweight/obesity in Portugal.[20] All administrative regions of mainland Portugal (Metropolitan Oporto, Trás-os-Montes and Douro river Valley—North; Mondego Valley, Beira Baixa and Beira Litoral—Portuguese Midlands; Algarve, Alentejo and Metropolitan Lisbon—South) were surveyed. Proportional stratified random sampling taking into account location (region) and number of students 10 to 18 years by age and sex in each school was used. Schools were randomly selected within each region until the established number of students by region was attained; details are described elsewhere.[20] This study was part of the *Midlands Adolescent Lifestyle Study* (MALS) and included 254 youth (114 boys, 140 girls), 13-16 years, resident in rural communities of the Portuguese Midlands. According to criteria of the Portuguese Statistical System,[21] rural communities were defined as having no more than 100 inhabitants/km^2 or a total population <2000. The majority of school youth (84%) lived in a house, whereas the remainder (16%) lived in a flat/apartment. Among fathers of the rural youth, 9% completed the highest level of schooling (college or university degree), whereas 26% completed the lowest level of education (9 years of compulsory schooling); corresponding educational levels among mothers were 13% and 25%, respectively.

The project was registered at the Portuguese Commission for Data Protection Science and Technology Foundation [SRFH/BD/38988/2007] and approved by the Scientific Committee of the University of Coimbra. Informed written assent was obtained from students and informed consent was obtained from parents or guardians.

Anthropometry

Measurements were taken by trained research assistants at each school. Height (nearest 0.1 cm) and weight (nearest 0.1 kg) were measured at the schools in the morning using a portable stadiometer (Harpenden model 98.603, Holtain Ltd, Crosswell, UK) and a portable scale (Seca model 770, Hanover, MD). Students wore T-shirts and shorts, and shoes were removed. WC was measured at the end of gentle expiration, midway between the lower rib margin and the iliac crest. Replicate measurements of WC were taken on 34 students within the same day. Technical errors of measurement (σ_e) and reliability (R) were calculated[22] and were as follows: 2.09 cm and 0.97, respectively. The body mass index (BMI) was calculated and youth were classified as normal weight, overweight, or obese using age-and sex-specific BMI cutoffs recommended by the International Obesity Task Force.[23]

SB and Daily PA

ActiGraph GT1M accelerometers (ActiGraph™, LLC, Fort Walton Beach, FL) were used to derive objective assessments of SB and PA. The device has been

validated in laboratory and free-living conditions with children and adolescents.[24] Students wore the accelerometer over the hip for 5 consecutive days (Thursday through Monday). It was held firmly in place with an elastic belt. Students were instructed to remove the monitor when involved in swimming activities or while showering. At the completion of the 5 days, the accelerometry data were electronically downloaded using the ActiLife software. The MAHUffe program (MAHUffe.exe, available from www.mrc-epid.cam.ac.uk) was used to reduce the data in a file containing minute-by-minute movement counts for each subject. Youth with incomplete records (those that failed to provide a minimum of 600 minutes of valid accelerometry per day) were excluded. Criteria for nonwear were defined as follows: 20 min of consecutive zeros, allowing for 2 minutes of interruptions. SB was estimated with a specific cut-point established against continuous measurement of energy expenditure (EE) by calorimetry,[25] and adjusted for total measured time. MVPA was determined using age-specific regression equations.[26] The cut points and inclusion criteria have been used in previous epidemiological studies of youth.[27] The output was expressed as average of minutes spent in MVPA, and as counts per minute, consistent with those investigations.

The 254 youth comprising the sample (83% of the initial sample, N = 297) were those who met the criteria for inclusion and were used for subsequent analyses. The remaining 43 rural youth failed to achieve 10 h of registered time on each of the 5 measured days.

Cardiorespiratory Fitness (CRF)

CRF was assessed with the 20-m shuttle-run test[28] and scored as the number of completed ''laps.'' Youth were required to run between 2 lines, 20 m apart using the cadence dictated by a CD emitting beep signals at prescribed intervals. The initial speed was set at 8.5 km/h for the first minute and was increased by 0.5 km/h each subsequent minute. The test provides a valid and reliable field measure of VO_{2max} in children and adolescents[28,29] and is frequently incorporated into the Portuguese physical education (PE) curriculum. The 20-m shuttle-run test was performed under standardized conditions in the gymnasium at each school. Tests were administered during a PE class after the anthropometry was completed. Time to complete the shuttle run and total running distance to the nearest completed lap were recorded. The number of completed laps was the CRF score used in the analysis. Replicate measurements of the 20-m shuttle-run test were taken on 23 students who performed the protocol twice, 1 week apart. The technical error and reliability coefficient were 2.6 laps (51.6 m) and 0.97, respectively.

Parental Education

Educational background of parents was used as a proxy for socioeconomic status. It was based on the Portuguese Educational System ([1] 9 years or less—subsecondary; [2] 10-12 years—secondary, and [3] higher education). The educational levels defined 3 socioeconomic categories: 1 = low (LE); 2 = middle (ME), and 3 = high (HE). Similar procedures have used in the Portuguese context.[30,31]

Statistical Analysis

Means and standard deviations (SD) were calculated for all variables. Prior to analysis, tests for normality were conducted on the indicators of SB, habitual PA (counts per minute), and moderate-to-vigorous PA (MVPA). PA measures were not normality distributed; log transformation (log 10) was used in the analysis. Sex-specific descriptive statistics were calculated for age, height, weight, WC, MVPA, CRF, SB, PA, and MVPA. One-way analysis of covariance (ANCOVA) was used to test the effect of sex, controlling for chronological age. Because individuals who are awake more hours in a day tend to have more time to be sedentary, measured time was also used as covariate in analyses of SB. All ANCOVAs were followed with Bonferroni-corrected post hoc tests.

Associations between WC and objectively assessed SB, controlling for the potentially confounding effects of chronological age, sex, MVPA, CRF, and parental education, were estimated using multiple linear regression analyses and expressed as beta values [β] and 95% confidence intervals [95%CI]. Four multivariate models were elaborated using a hierarchical model protocol: Model 1 (SB was the sole predictor of SB [crude]), Model 2 (SB, chronological age, and sex), Model 3 (SB, chronological age, sex, MVPA, and CRF) and Model 4 (SB, chronological age, sex, MVPA, CRF, and parental education). Significance was set at 5%. SPSS 17.0 (SPSS Inc., Chicago, IL) was used.

RESULTS

Characteristics of the sample stratified by sex are summarized in Table 1. Based on the BMI, weight status of the sample was as follows: boys—79% normal weight, 16% overweight, 5% obese; girls—76% normal weight, 19% overweight, 5% obese. Height and weight were, on average, significantly greater in boys than in girls, but the sexes did not differ in chronological age and WC.

Rural boys spend significantly more time than girls in PA and MVPA on both week and weekend days, whereas girls spend significantly more time than boys in SB on week days and the total of 5 measured days. The sexes do not significantly differ in SB on weekend

Table 1. **Descriptive Statistics and Results of ANCOVAs (Chronological Age as Covariable) of the Effect of Sex on Body Size, Sedentary Behavior, Physical Activity, and Aerobic Endurance**

Variables	Boys (N = 114) mean ± SD	Girls (N = 140) mean ± SD
Antropometry		
Chronological age (years)	14.3 ± 1.1	14.3 ± 1.0
Height (cm)	165.1 ± 8.9	158.2 ± 6.4**
Weight (kg)	56.6 ± 11.6	53.5 ± 10.0**
WC (cm)	76.5 ± 8.2	77.2 ± 7.7
BMI (kg/m^2)	20.62 ± 3.19	21.34 ± 3.53
Physical activity/sedentary behavior		
MT (week days) min/day	888.9 ± 51.4	890.4 ± 56.7
MT (weekend days) min/day	789.8 ± 77.8	783.2 ± 75.1
MT (total of 5 days) min/day	849.2 ± 47.3	847.4 ± 49.5
SB† (week days) min/day	725.7 ± 61.0	743.4 ± 60.7**
SB† (weekend days) min/day	670.9 ± 84.5	676.2 ± 80.2
SB† (total of 5 days) min/day	703.7 ± 58.1	716.4 ± 55.7**
PA‡ (week days) counts/min/day	510.2 ± 167.5	434.6 ± 124.4**
PA‡ (weekend) counts/min/day	391.0 ± 161.8	346.7 ± 136.4*
PA‡ (total of 5 days) counts/min/day	462.5 ± 142.3	399.5 ± 115.7**
MVPA‡ (week days) min/day	91.3 ± 36.9	76.2 ± 29.3**
MVPA‡ (weekend days) min/day	53.0 ± 35.8	43.2 ± 28.1*
MVPA‡ (total of 5 days) min/day	75.9 ± 31.3	62.9 ± 26.1**
Physical fitness		
CRF, # completed laps	70.4 ± 22.9	41.0 ± 15.5**

* $p < .05$; ** $p < .01$.
MT, measured time.
†Adjusted for measured time.
‡Log-transformed values were used in the analysis.

days. Boys also have significantly higher levels of CRF than girls.

Results of the regression analyses are summarized in Table 2. SB was not significantly associated with the WC, neither in the unadjusted model ($\beta = 0.014$; 95% CI: −0.08 to 0.11) nor after adjustment for all potential confounders (model 4) ($\beta = 0.03$; 95% CI: −0.08 to 0.14). In the final model, the unique significant predictor of the WC was cardiorespiratory fitness ($\beta = -0.82$; 95% CI: −1.02 to −0.62); rural adolescents with higher levels of CRF presented lower WC rates compared with less fit adolescents.

DISCUSSION

Several studies have examined relationships between indicators of adiposity and SB in adolescents.[32,33] However, systematic evaluation of the independent contribution of WC to time devoted in sedentary activities in rural school youth and perhaps other understudied populations is lacking. Contrary to our expectations, the findings showed no significant relationship between WC and SB in rural Portuguese adolescents. Moreover, that trend was not altered after adjustment for several potential confounding factors, including MVPA.

Previous studies have suggested that SB and PA should be considered as separated behaviors, which affect adiposity and metabolic variables in the paediatric population in different ways.[33-35] The physiological link between SB and WC is apparently supported by unhealthy food habits during periods of SB, eg, consumption of fried foods and snacks, among other energy- and fat-dense foods.[36,37] By inference, the literature suggests a need for public actions targeting to decrease the time spent in SB in pediatric-age populations in Portugal.[29] Despite of this study did not reveal a significant association between WC and SB, it is relevant from the perspective of elevated prevalence SB, and overweight/obesity rates among adolescents in southern communities of Europe. This cross-sectional analysis still gains stronger interest because studies claim to analyze the relationships between objectively measured SB and central obesity of school adolescents from southern Europe where overweight rates are especially higher in comparison with youth from northern of Europe.

Contemporary lifestyles are often implicated in the epidemic of ''diseases of Western civilization'' because children and adolescents are seen as particularly vulnerable to the influence of electronic media. From the point of view of clinical and educational intervention design, screen time assessment is an attractive target for several reasons: first, increased screen time is known to be associated with excessive adiposity in young people[32,33,35] and second, it is relatively easy to assess among children and adolescents. On the other hand, previous studies have consistently reported higher TV viewing among rural compared with urban school peers.[10,38] Moreover, it has been suggested that each additional hour of time spent watching TV was associated with an increased risk of overweight and excess body fat by 15.8% and 26.8%, respectively, among Spanish youth.[39] The potential positive relationship between SB and obesity in youth (which, however, did not have statistical significance in the present study) is particularly of concern because SB is related to higher metabolic risk; and the effect of SB on metabolic risk is, in part, mediated by its action on adiposity.[35]

TV viewing and computer are commonly used as proxy indicators of daily sedentary time. They are, however, not the only form of SB in school adolescents, who also spend substantial amounts of time sitting in school classes, riding in cars, eating, socialising, reading, and studying.[40] School activities contributed 42% of nonscreen sedentary time among Australian adolescents whereas socialising, self-care (mainly eating), and passive transport, 19%, 16%, and 15%, respectively.[40] Screen time was also negatively correlated with nonscreen sedentary time ($r = -.58$) and moderately correlated with total sedentary time ($r = .53$). By inference, screen time was only a

Table 2. **Crude and Adjusted Relationship Between WC and SB in Rural School Adolescents**

	Waist circumference						
			Unstandardized coefficients		95% CI for beta		
Model*	R^2	Adjusted R^2	Beta	SD	Lower	Upper	Standardized beta coefficient
1	10.1%	1.0%	0.01	0.05	−0.08	0.11	0.02
2	41.9%	17.5%	−0.03	0.04	−0.11	0.06	−0.04
3	59.1%	34.9%	0.03	0.05	−0.07	0.14	0.05
4	59.2%	35.1%	0.03	0.05	−0.08	0.14	0.05

*Model 1 = unadjusted; Model 2 = adjusted for chronological age, and sex; Model 3 = model 2 + adjusted for MVPA and CRF; Model 4 = model 3 + adjusted for parental education.

moderately effective surrogate for total sedentary time in Australian youth who spent, on average, 345 min per day in nonscreen sedentary time (60% of total sedentary time). In this study of Portuguese youth, percentages of time in nonscreen sedentary activities were 71% and 76% for rural boys and girls, respectively.

Transport to school may be an additional factor that contributes to high levels of SB among rural Portuguese youth. In an earlier study of adolescents from the Midlands, a greater percentage of urban than rural youth walked to school, whereas a greater percentage of rural than urban youth used public transport.[7] Several studies of children and adolescents have reported that, irrespective of sex, active transportation to and from school was significantly more probably in neighborhoods with better street connectivity, mixed land use and/or higher population densities.[41,42] More time spent in passive commuting may thus be an additional factor contributing to the relationship between SB and WC. Further, in addition to overall PA, specific domains of PA should be considered in comparisons of urban and rural adolescents. This may be relevant because some PA domains are particularly more important than others in the prevention of cardiovascular and metabolic diseases among pediatric populations.[43]

Although time spent outdoors is positively related PA in school youth,[44] less access to sport facilities in rural communities may be a factor which contributes to higher levels of SB. Further, neighborhoods with recreational facilities and infrastructure for walking and cycling are important predictors of active behaviors.[45] It is possible that rural adolescents were more likely to be sedentary due in part to limited access to sport/recreational facilities and community infrastructure. Unfortunately, community facilities and infrastructure were not considered in this study.

On the other hand, the final statistical model of this study revealed that rural adolescents with higher levels of CRF presented lower WC compared with less aerobic fit adolescents. This observation was consistent with previous studies that documented low levels of CRF as strongly and independently associated with high adiposity as indicated by BMI and skinfolds thicknesses[46] and WC.[47] Because the 20-m shuttle-run test is part of Portuguese PE curriculum, schools are important in the identification of adolescents at high-risk overweight/obesity and/or low CRF, and in providing resources for specific programs targeting these youth to enhance CRF. Collectively, the studies highlight the importance of increasing CRF as a preventive strategy among adolescents.

In summary, identifying the detailed associations between SB and specific components of cardiometabolic risk factors is important to inform primary prevention and future interventions aimed at decreasing sedentary habits and enhancing CRF in young people. Observations in this study are perhaps the first to suggest no significant relationship between WC and objectively measured time in SB in rural youth from southern of Europe. The results are not consistent with previous observations in adolescents from more densely populated developed communities (or urban communities). In part, those results are quite interesting because may unveil some bias associates to epidemiological studies which including a large range of geographic or ethnic diversity; in other words, specific features of population minorities might be hidden and consequently misevaluated. Therefore, future research is really claimed among rural adolescents in different geographic contexts to try to clarify recent findings from less studied communities.

Several limitations of the study need to be recognized. The study was cross-sectional so that cause-effect relationships cannot be assumed. The results are limited to a relatively small sample of school Portuguese youth from 13 to 16 years of age living in the Midlands. Thus, generalization of the results to other samples of adolescents in Portugal or in other countries should be performed with care. Third, features of the built environment in rural Portuguese communities were not considered. Specific aspects of the built environment in rural areas may impact physical inactivity among children, but these specific features need to be identified and systematically studied.

In conclusion, and contrary to finding from several epidemiological studies, which are usually performed with urban and mixed-ethnic samples of adolescents, WC was not significantly associated with time devoted in SB in rural school adolescents. Furthermore, rural adolescents with higher levels of CRF presented lower WC compared with less aerobic fit adolescents.

IMPLICATIONS FOR SCHOOL HEALTH

The results of the current study highlights the need to encourage the improvement of the CRF in youth as one of a number of potential school strategies to avoid the substantial increasing of health risk behaviors associated to adiposity during adolescence. For example, Taliaferro et al[48] suggest that participation in organized sports affords many health benefits to most adolescents. Therefore, promoting the sport participation, which correlates with reduced involvement in multiple health risk behaviors among adolescents, might represents a crucial contribution to health policy and practice.[49] Furthermore, other school interventions might include (1) implementation of District Wellness Plan recommendations (ie, in rural communities) for healthy lifestyles; (2) establishment of school wellness teams to address health-related priorities specially associated to weight control and improvement cardiorespiratory fitness; (3) disseminate school strategies to promote friendly school climate and encourage before-/after-school programs to promote health and active lifestyle learning.

Future research should extend similar design in other rural communities and assess multiple adiposity and SB variables to confirm or not some of the aforementioned findings. In addition, and because WC was not significantly associated with time devoted in SB in rural school adolescents of this study, further variables of the other side of the energy balance should be explored, particularly adolescent nutritional habits and its implications on adiposity of school people.

Human Subjects Approval Statement

This study was approved by the University of Coimbra's institutional review board and the Portuguese Commission for Data Protection/Science and Technology Foundation (SRFH/BD/38988/2007) approved all procedures.

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