Preventive Medicine Reports 10 (2018) 221–226

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Environment perception and leisure-time physical activity in Portuguese high school students

Rita Pereira[a], Rute Santos[a,b,c], Susana Póvoas[a,d], Pedro Silva[b,*]

[a] University Institute of Maia, ISMAI, Maia, Portugal
[b] Research Center in Physical Activity, Health and Leisure, Faculty of Sport, University of Porto, Porto, Portugal
[c] Early Start Research Institute, School of Education, Faculty of Social Sciences, University of Wollongong, Wollongong, Australia
[d] Research Center in Sports Science, Health Sciences and Human Development, CIDESD, Vila Real, Portugal

ARTICLE INFO

Keywords:
Environment perception
Physical activity
Adolescents
ALPHA questionnaire

ABSTRACT

This study aims to analyze the association between perceived environmental factors and leisure-time physical activity (PA) among adolescents of both genders. Data were collected in autumn of 2011 from 866 adolescents (412 girls and 454 boys) 12- to 18-years-old, from four Portuguese cities. Perception of environmental factors was assessed by Assessing Levels of Physical Activity and Fitness (ALPHA) questionnaire (Spittaels et al., 2010, IJBNPA). PA was assessed by a questionnaire that evaluated PA during leisure-time and participants were assigned into the following categories: sedentary; low active; moderate active; and very active. Boys presented higher levels of structured PA, frequency and intensity of PA, and level of sport competition than girls ($p < 0.001$). Distance to local facilities ($p = 0.001$ for girls; $p < 0.001$ for boys) and home environment ($p = 0.004$ for girls; $p = 0.015$ for boys) were negatively associated with PA. Total, cycling and walking infrastructures ($p < 0.001$), as well as cycling and walking network ($p = 0.049$) and connectivity ($p = 0.034$) showed a positive association with PA in boys. Analysis of variance showed significant differences between girls' PA regarding aesthetics ($p = 0.013$), study environment ($p = 0.023$), home environment ($p = 0.014$) and whether it is pleasant or not ($p = 0.023$). Differences between boys' PA were observed for distance to local facilities ($p = 0.003$), total, cycling and walking infrastructures ($p < 0.001$) and home environment ($p = 0.002$). This study results support that some environmental factors are associated with adolescents' PA levels, with relevant differences between genders. Therefore, these gender differences must be taken into account, in order to increase levels of PA in Portuguese youth, especially in girls.

1. Introduction

Physical activity (PA) has a wide spectrum of benefits in all health domains, decreasing the risk of several diseases, as diabetes, hypertension, cancer, osteoporosis and also mental problems (Friedenreich and Orenstein, 2002; Goodwin, 2003; Moreira et al., 2014; Padilla et al., 2005; van Dijk et al., 2013). It improves cardiorespiratory fitness and quality of life (Lin et al., 2015; Perales et al., 2014). In addition, being engaged in high levels of PA seems to be related to healthy behaviors, while low levels of PA are associated with several risk behaviors, suggesting that PA could be crucial in preventing detrimental behaviors and promoting healthy ones, and consequently, leading to a healthier lifestyle (Delisle et al., 2010; Dinger and Vesely, 2001). Moreover, the benefits of PA could be extended to economic and environmental issues such as lower health care costs, increased productivity, lower traffic and gas emission (Davis et al., 2007; WHO, 2003).

Regardless of these evidences, low levels of physical activity are still observed in both adolescents and adults in several countries. A study aiming at describing physical activity levels worldwide concluded that 31% of adults and 80% of adolescents are inactive (data from 122 and 105 countries, respectively) (Hallal et al., 2012). The results are equally discouraging for European countries. < 50% of children and adolescents achieve the physical activity guidelines in most of European countries (Van Hecke et al., 2016). Only 36.4% of Portuguese children between 10- to-11 years achieve the PA recommendations and adolescents show the lowest values (4.1% for 16- to 17-years-old) (Baptista et al., 2012). Thus, it becomes imperative to understand which factors are capable of changing this condition, and motivate people to become active, especially among youth.

Environment influences life of young people (Committee on Environmental Health and Tester, 2009) and research on the

* Corresponding author at: Faculty of Sport, University of Porto, R. Dr. Plácido da Costa 91, 4200-450 Porto, Portugal.
E-mail address: pedrosilva@fade.up.pt (P. Silva).

https://doi.org/10.1016/j.pmedr.2017.10.013
Received 28 December 2016; Received in revised form 13 October 2017; Accepted 23 October 2017
Available online 26 October 2017

environmental factors that influence PA has grown (Active Living Research, 2012). A large spectrum of these factors have been studied, such as: residential density, land use mix, distance to local facilities, walking and cycling infrastructures, recreation facilities, safety from crime and traffic, aesthetics, connectivity, walkability, social environment, distance to school, study environment, home environment. A positive correlation between PA and all the above-mentioned characteristics is expected, except for distance to local facilities and school, since when distance increases, the level of PA decreases (Ding et al., 2011). However, despite previous reviews find some studies that support the assumption above, there is no consistence between all studies included (Ding et al., 2011; Ferreira et al., 2006; McGrath et al., 2015). In Ding et al. (2011) review, almost all studies included found that the association between environmental factors and PA is in the expected direction, however only the association between land use mix and residential density with PA presented consistent conclusions. McGrath et al. (2015) also analyzed a large variety of environmental factors, however significant positive associations with PA were found only for play spaces, walkability sidewalks, land use mix and more curl-de-sacs, which promote less traffic, but also less connectivity. A negative association was found between traffic infrastructures and less traffic safety and PA. This study also showed that effect of built-environment factors in play or walking support is different between children and adolescents, as well as, between the genders in both age stages (McGrath et al., 2015). Furthermore, boys are more active than girls, and also seem to present higher environmental perception scores (Garcia-Cervantes et al., 2015). Thus, children and adolescents, and boys and girls should be analyzed separately.

The purpose of this study is to analyze the association between perceived environmental factors and leisure-time PA levels among adolescents of both genders.

2. Methods

2.1. Study design and participants

This is a school-based prospective cohort study carried out in four Portuguese cities from the Portuguese North Region during autumn 2011. Participants' recruitment was conducted at the enrolled schools. Students from the 7th and 10th grades were invited to participate in the study.

Data was collected for 866 adolescents, aged 12 to-14 years (7th grade) and 15 to-18 years (10th grade). The study was conducted in accordance to the World Medical Association's Helsinki Declaration for Human Studies (World Medical Association, 1989). The Portuguese Data Protection Authority (#1112434/2011) and the Portuguese Ministry of Science and Education (0246200001/2011) approved the study. All participants were informed of the purpose of the study. Students gave their verbal assent and written informed consent to participate was provided by their parents or guardians.

2.2. Anthropometrics

A digital scale (Tanita Inner Scan BC 532, Tokyo, Japan) and a portable stadiometer (Seca 213, Hamburg, Germany), were used to determine body mass and stature, respectively. All measurements were performed with the participants in light clothing, without shoes, and according to standard procedures (Lohman et al., 1988). Body mass index (BMI) was calculated using the standard formula BMI = weight/height^2.

2.3. Environment perception

Perception of environmental factors was assessed by the adapted version of the ALPHA questionnaire developed by Spittaels et al. (2010) which has shown a good validity and reliability for the European population. This questionnaire was originally developed by Spittaels et al. (2009), purposing to establish standard devices to access perceived environmental measures in relation to PA. It takes into account the European specific contexts, the different kinds of PA (active travel, PA at work/school, PA at home/leisure), standard definition about neighborhood (area/distances) and walking as well cycling behavior.

The ALPHA questionnaire included questions on: types of residences in the neighborhood (3 items), distance to local facilities (8 items), walking and cycling infrastructures in the neighborhood (4 items), maintenance of walking and cycling infrastructures in the neighborhood (3 items), neighborhood safety (6 items), how pleasant is the neighborhood for walking or cycling (4 items), walking and cycling network (4 items), home environment (6 items), workplace or study environment (11 items). The answers were evaluated using a scale (1 to 5), and the sum of the item values was calculated for each question.

2.4. Physical activity

PA was assessed by a 5-item self-report questionnaire that evaluated physical activities during leisure-time (Telama et al., 1997). This questionnaire has shown to possess good test–retest reliability among Portuguese adolescents (intraclass correlation coefficient, 0.92–0.96) (Mota and Esculcas, 2002). It allows the analysis of different domains of PA, namely: structured PA (sport activities or formal exercise programs) and non-structured PA (without integrating any club or not guided by a trainer) and frequency of PA (from never, monthly, weekly, to almost every day); intensity of PA (from 0 to 7 or more hours spend in physical activities that make the participant breath hard and sweat); and participation in sport competition (school, club, national or international level).

All answers were evaluated using a 1 to 4 scale. A total index (ranging from 5 to 20 points) was derived from this questionnaire, and the participants were assigned in the following categories: sedentary (SD) (5 points); low active (LA) (6 to 10 points); moderate active (MA) (11 to 15 points); and very active (VA) (> 15 points) (Ledent et al., 1997).

2.5. Statistical analyses

Descriptive statistics (means and standard deviations) were calculated to describe participants' characteristics. The Student's unpaired *t*-test was used to assess differences between genders concerning age, anthropometric measures and perceived environmental factors responses.

The Chi-square test was used to determine the proportion of differences by PA levels and by gender in the PA questionnaire.

Bivariate associations between PA levels and perceived environmental factors were evaluated using Spearman correlation. Differences between PA levels related to perceive environmental factors were assessed by one-way analysis of variance. In case of significant differences between PA levels a pairwise comparison with Bonferroni test was applied to locate the differences.

The significance level was set at 5% and the Statistical Package for the Social Sciences (SPSS Inc. version 20.0, IBM, Armonk, New York, USA) was used for all analyses.

3. Results

Participants' characteristics are shown in Table 1. Boys are older ($p = 0.010$), higher and heavier ($p < 0.001$) than girls. Girls presented a higher BMI, however without significant differences. More than half of all participants are moderate or very active but boys are more active than girls ($p < 0.001$). Boys also presented higher levels of structured PA, frequency and intensity of PA, and level of sport competition than girls ($p < 0.001$) (data not shown).

Table 2 presents the Spearman correlation results: *Distance to local*

Table 1
Participants' characteristics (mean ± SD) and physical activity levels (%).

Variables	All (n = 866)	Female (n = 412)	Male (n = 454)	*p* value
Age (years)	14.4 ± 1.8	14.3 ± 1.7	14.6 ± 1.8	0.010
Body mass (kg)	55.6 ± 12.8	53.3 ± 11.0	57.6 ± 14.0	< 0.001
Stature (m)	1.61 ± 0.1	1.57 ± 0.7	1.64 ± 0.1	< 0.01
Body mass index (kg/m^2)	21.3 ± 3.7	21.4 ± 3.8	21.2 ± 3.7	N.S.
Sedentary	4.4%	6%	3%	< 0.001
Low active	37.8%	47%	29%	
Moderate active	47.1%	42%	52%	
Very active	10.7%	5%	16%	

Table 2
Spearman correlations between perceived environmental factors and physical activity (total index) by gender.

Variables	Female		Male	
	Rho	*p* value	Rho	*p* value
Residential density	− 0.035	N.S.	0.068	N.S.
Distance to local facilities	− 0.156	0.001	− 0.177	< 0.001
Total infrastructure	0.063	N.S.	0.222	< 0.001
Walking infrastructure	0.046	N.S.	0.190	< 0.001
Cycling infrastructure	0.053	N.S.	0.189	< 0.001
Maintenance	− 0.004	N.S.	0.036	N.S.
Total safety	− 0.012	N.S.	− 0.002	N.S.
Safety from crime	− 0.024	N.S.	− 0.027	N.S.
Safety from traffic	− 0.016	N.S.	0.007	N.S.
Pleasant	0.081	N.S.	0.018	N.S.
Aesthetics	0.069	N.S.	− 0.006	N.S.
Cycling and waking network	− 0.004	N.S.	0.093	0.049
Connectivity	0.006	N.S.	0.099	0.034
Home environment	− 0.142	0.004	− 0.115	0.015
Study environment	0.042	N.S.	0.003	N.S.

facilities and *Home environment* were negatively associated with PA total index in girls (Rho = − 0.156, $p = 0.001$ and Rho = − 0.142, $p = 0.004$, respectively) and boys (Rho = − 0.177, $p < 0.001$ and Rho = − 0.115, $p = 0.015$) respectively. It's also shown a positive association between *Total infrastructure* (Rho = 0.222, $p < 0.001$), *Walking infrastructure* (Rho = 0.190, $p < 0.001$) and *Cycling infrastructure* (Rho = 0.189, $p < 0.001$), as well as *Cycling and walking network* (Rho = 0.093, $p = 0.049$) and *Connectivity* (Rho = 0.099, $p = 0.034$) with PA in boys.

Differences between perceived environmental factors and PA levels among girls and boys are presented in Table 3. Differences between PA levels of girls were shown for some dimensions, namely: *Pleasant* ($p = 0.023$), *Aesthetics* ($p = 0.013$), *Home environment* ($p = 0.014$) and *Study environment* ($p = 0.023$). In boys the differences between PA level are relative to dimensions: *Distance to local facilities* ($p = 0.003$), *Total infrastructure*, *Walking infrastructure* and *Cycling infrastructure* ($p < 0.001$ for all) and *Home environment* ($p = 0.002$).

Figs. 1 and 2 display perceived environmental factors by PA level for girls and boys, respectively. A Bonferroni test allowed to find differences between girls' PA levels in *Aesthetics* (LA vs MA, $p = 0.016$), *Home environment* (LA vs MA, $p = 0.048$) and *Study* environment (SD vs LA, $p = 0.024$). Among boys, differences were shown for: *Distance to local facilities* (LA vs MA, $p = 0.026$; LA vs VA, $p = 0.009$); *Total infrastructure* (VA vs SD, LA, MD, $p < 0.001$); *Walking infrastructure* (VA vs SD, $p = 0.023$; VA vs LA, $p = 0.002$); *Cycling infrastructures* (VA vs SD, $p = 0.003$; VA vs LA, $p < 0.001$; VA vs MA, $p < 0.001$); *Home environment* dimension (SD vs LA, $p = 0.024$; SD vs MA, $p = 0.003$; SD vs VA, $p = 0.002$).

Table 3
Analysis of variance of perceived environmental factors according to PA levels by gender.

Variables	Female	Male
	F; *p* value	F; *p* value
Residential density	(2.604; N.S.)	(1.533; N.S.)
Distance to local facilities	(2.582; N.S.)	(4.711; $p = 0.003$)
Total infrastructure	(0.907; N.S.)	(12.302; $p < 0.001$)
Walking infrastructure	(0.623; N.S.)	(6.105; $p < 0.001$)
Cycling infrastructure	(0.762; N.S.)	(10.512; $p < 0.001$)
Maintenance	(1.404; N.S.)	(0.654; N.S.)
Total safety	(0.087; N.S.)	(0.946; N.S.)
Safety from crime	(0.638; N.S.)	(1.646; N.S.)
Safety from traffic	(0.278; N.S.)	(0.328; N.S.)
Pleasant	(3.206; $p = 0.023$)	(0.429; N.S.)
Aesthetics	(3.611; $p = 0.013$)	(0.874; N.S.)
Cycling and waking network	(0.079; N.S.)	(1.720; N.S.)
Connectivity	(0.024; N.S.)	(1.783; N.S.)
Home environment	(3.577; $p = 0.014$)	(5.085; $p = 0.002$)
Study environment	(3.202; $p = 0.023$)	(1.195; N.S.)

4. Discussion

The aim of this study was to analyze the association between perceived environmental factors and leisure-time PA levels among Portuguese adolescents of both genders.

The findings of this study showed that adolescent boys are significantly more active than girls ($p < 0.001$). Concerning boys PA levels, 52% of the participants were considered moderate active (MA) and 16% very active (VA), whereas girls had lower PA levels 42% MA and only 5% were VA. Our results report that < 10% of both genders are considered sedentary. Previous studies have shown similar results (Mota and Esculcas, 2002; Sallis et al., 2000; Santos et al., 2009). Mota and Esculcas (2002) analyzed the physical activity level of Portuguese adolescents using the same method and also concluded that boys present higher levels of PA, whereas a higher number of girls belong to the low active or sedentary group. Besides that, boys also prefer structured and girls unstructured activities.

Distance to local facilities was inversely associated with PA in both genders (Rho = − 0.156, $p = 0.001$ for girls; Rho = − 0.177, $p < 0.001$ for boys). Other studies also found an inverse association between distance to recreation facilities, public parks or playgrounds (included in this dimension) and PA in girls (Patnode et al., 2010) and in both genders (Grow et al., 2008). On the other hand, a higher land use mix leads to lower distances to facilities (Deforche et al., 2010), considering that different kinds of trades and services as well as habitations are located in the same area. Positive associations between land use mix and PA (by active travel) were found previously (De Meester et al., 2014; Deforche et al., 2010; Larsen et al., 2009). De Farias Junior et al. (2011) shows that living at walking distance from places where adolescents like to be was directly associated with PA levels on this population.

For boys, dimensions *Total infrastructure* (Rho = 0.222, $p < 0.001$), *Walking infrastructure* (Rho = 0.190, $p < 0.001$) and *Cycling infrastructure* (Rho = 0.189, $p < 0.001$) showed a positive association with PA. However, a negative correlation between walking infrastructure and PA by active travel was found by De Meester et al. (2013). These authors suggested that adolescents choose to walk by paths without sidewalks or in bad conditions. Other authors did not find any significant association between these infrastructures and levels of PA in adolescents (Deforche et al., 2010; Mota et al., 2005).

A positive correlation between cycling and walking network (Rho = 0.093, $p = 0.049$) and connectivity (Rho = 0.099, $p = 0.034$) was shown among boys. Previous studies support our findings for both dimensions. De Meester et al. (2013) described that the existence of more connected streets is positively associated with more minutes per

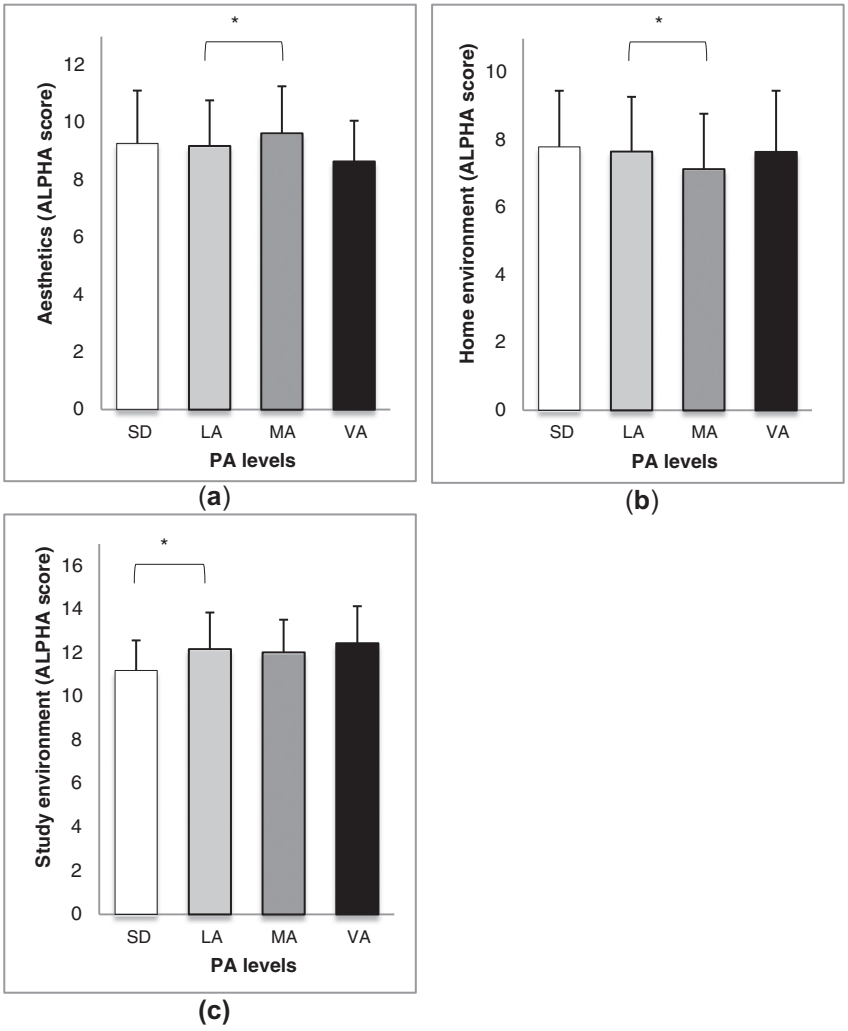

Fig. 1. (a) Aesthetics, (b) home environment and (c) study environment according to physical activity intensity among girls. Values in mean ± standard deviations. Physical activity (PA). Sedentary (SD), low active (LA), Moderate active (MA), very active (VA). Significant differences between groups, $*p < 0.05$.

day spend in active travel. Deforche et al. (2010) found a similar association with active travel as well. Patnode et al. (2010) also found a positive correlation between PA and cycling and walking network, though only for girls. However, negative correlations with PA were found in some studies, regarding network (Hobin et al., 2012) and connectivity (Norman et al., 2006). A possible explanation given by the authors is that in streets with less connectivity and more curl-de-sacs, youth are safer from traffic and could play and be active in these low-traffic streets.

An inverse correlation was found between home environment and PA in both genders (Rho = −0.142, $p = 0.004$ for girls; Rho = −0.115, $p = 0.015$ for boys). This dimension includes the access of PA equipment or infrastructure, access to a vehicle and dog ownership. Some studies have shown that access to PA equipment, not having access to a vehicle and owning a dog can promote PA (Alton et al., 2007; Deforche et al., 2010; Patnode et al., 2010; Sirard et al., 2010). Although, that was not the case for our findings concerning this dimension.

Analysis of variance results highlight some previous findings for boys, showing that higher PA levels present lower values relative to *Distance to local facilities* ($p = 0.003$). Once again, among boys, differences between categories of PA levels were found for dimensions relative to infrastructures (walking and cycling included). In fact, boys considered MA or VA present higher values for these dimensions than LA or SD ones ($p < 0.001$). For *Home environment* it was found that values of this dimension decrease when PA levels increases for both genders ($p = 0.014$ for girls; $p = 0.002$ for boys).

There were additional significant differences between PA levels in girls regarding *Pleasant* and *Aesthetics* ($p = 0.023$ and $p = 0.013$, respectively). MA girls present high values in both dimensions in comparison with less active girls. These results are consistent with previous findings that found girls who fulfil current PA recommendations report positive perception of the environmental aesthetics (De Farias Junior et al., 2011). Mota et al. (2005) reported the same for both genders. Additionally, adolescents with better aesthetics neighborhoods were more likely to be active. Moreover, Deforche et al. (2010) reported that higher levels of PA by AF in adolescents of both genders were associated with more attractive environments.

VA girls revealed the lowest values for dimensions *Pleasant* and *Aesthetics*. De Meester et al. (2014) found similar results in a research about the relation of parents' environmental factors perception with PA and active travel of children. A possible explanation for this finding can be that more active girls who practice PA outside have more tolerance to notice less enjoyable backgrounds.

Relative to *Study environment*, differences between PA levels were found only for girls ($p = 0.023$). As expected, girls with high levels of PA present high values for this dimension. Other studies regarding this subject support our results, namely: distance to school (De Meester et al., 2013; Graham et al., 2014; Patnode et al., 2010) access, maintenance and quantity of PA equipment or facilities (Haug et al., 2010;

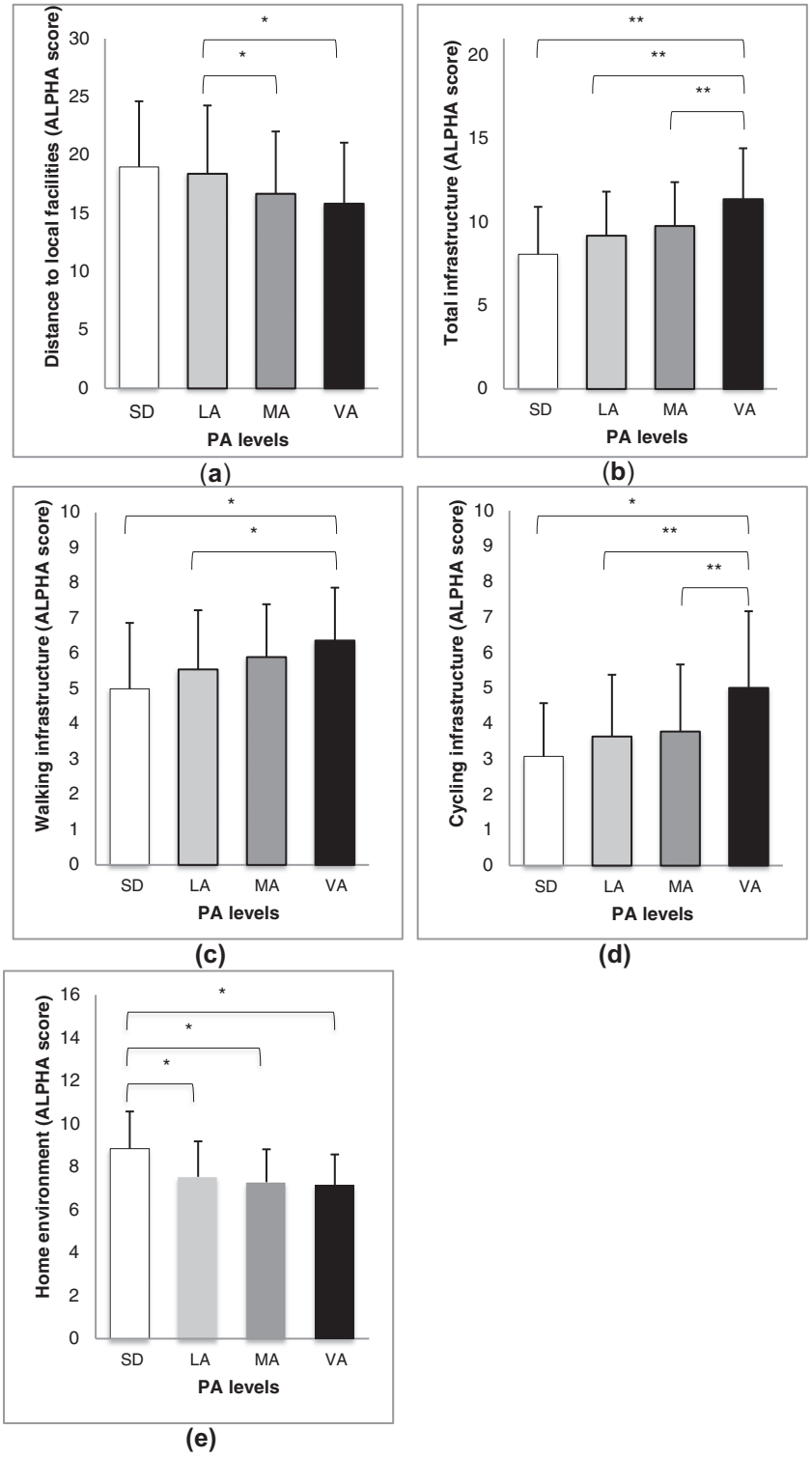

Fig. 2. (a) Distance to local facilities, (b) total infrastructure, (c) walking infrastructure, (d) cycling infrastructure and (e) home environment according to physical activity intensity among boys. Values in mean ± standard deviations. Physical activity (PA), sedentary (SD), low active (LA), moderate active (MA), very active (VA). *$p < 0.05$ and **$p < 0.001$.

Hobin et al., 2012; Ishii et al., 2014) and Physical Education classes (Hobin et al., 2012).

Identifying environmental factors that promote physical activity is of the most importance in order to inform policy makers and urban planners that will develop existing neighborhoods or planning new ones (De Meester et al., 2012). However, environmental factors influence physical activity in different ways, as well as, perception of environment factors and its association with PA is different between genders. Thus, a specific knowledge about the population of the target residential area, should be taken in advanced.

This study presents evidence on the association between environmental factors and leisure-time PA levels among Portuguese adolescents, extending knowledge in this field. Nevertheless, there are some limitations to report: firstly, the cross-sectional nature of this study does

not reflect a direction of causality. Hence, more studies with longitudinal focus should be developed; secondly, this study design and participants' selection are not enough for a generalization of the results to a national scale; and finally the use of subjective methods for measuring PA levels and environment perception may introduce bias in the results. However, to minimize this aspect, questionnaires that previously have shown good reliability and validity were used.

Strengths of this study include: analyses of a relevant group of participants; the fact that few studies on this topic had been done in this population; and differences between genders have been considered. As shown, girls and boys present different PA levels, different perceived environment and different levels of association between these dimensions.

5. Conclusions

This research leaded us to important results about the association between PA levels and perceived environmental factors among Portuguese adolescents. It suggests that boys and girls present different perceptions regarding environment factors and therefore, differences between genders must be considered in further investigations. The environment characteristics that should be considered when planning PA interventions were highlighted, namely: distance to local facilities, walking and cycling infrastructures, connectivity and network, pleasant and aesthetics and home and study environment.

References

Active Living Research, 2012. Reference List by Year.

Alton, D., Adab, P., Roberts, L., Barrett, T., 2007. Relationship between walking levels and perceptions of the local neighbourhood environment. Arch. Dis. Child. 92, 29–33.

Baptista, F., Santos, D.A., Silva, A.M., et al., 2012. Prevalence of the Portuguese population attaining sufficient physical activity. Med. Sci. Sports Exerc. 44, 466–473.

Committee on Environmental Health, Tester, J.M., 2009. The built environment: designing communities to promote physical activity in children. Pediatrics 123, 1591–1598.

Davis, A., Valsecchi, C., Fergusson, M., 2007. Unfit for Purpose: How Car Use Fuels Climate Change and Obesity. Institute for European Environmental Policy, London.

De Farias Junior, J.C., Lopes Ada, S., Mota, J., Santos, M.P., Ribeiro, J.C., Hallal, P.C., 2011. Perception of the social and built environment and physical activity among Northeastern Brazil adolescents. Prev. Med. 52, 114–119.

De Meester, F., Van Dyck, D., De Bourdeaudhuij, I., Deforche, B., Sallis, J.F., Cardon, G., 2012. Active living neighborhoods: is neighborhood walkability a key element for Belgian adolescents? BMC Public Health 12, 7.

De Meester, F., Van Dyck, D., De Bourdeaudhuij, I., Deforche, B., Cardon, G., 2013. Does the perception of neighborhood built environmental attributes influence active transport in adolescents? Int. J. Behav. Nutr. Phys. Act. 10.

De Meester, F., Van Dyck, D., De Bourdeaudhuij, I., Cardon, G., 2014. Parental perceived neighborhood attributes: associations with active transport and physical activity among 10–12 year old children and the mediating role of independent mobility. BMC Public Health 14.

Deforche, B., Van Dyck, D., Verloigne, M., De Bourdeaudhuij, I., 2010. Perceived social and physical environmental correlates of physical activity in older adolescents and the moderating effect of self-efficacy. Prev. Med. 50 (Suppl. 1), S24–9.

Delisle, T.T., Werch, C.E., Wong, A.H., Bian, H., Weiler, R., 2010. Relationship between frequency and intensity of physical activity and health behaviors of adolescents. J. Sch. Health 80, 134–140.

van Dijk, J.W., Venema, M., van Mechelen, W., Stehouwer, C.D., Hartgens, F., van Loon, L.J., 2013. Effect of moderate-intensity exercise versus activities of daily living on 24-hour blood glucose homeostasis in male patients with type 2 diabetes. Diabetes Care 36, 3448–3453.

Ding, D., Sallis, J.F., Kerr, J., Lee, S., Rosenberg, D.E., 2011. Neighborhood environment and physical activity among youth a review. Am. J. Prev. Med. 41, 442–455.

Dinger, M.K., Vesely, S.K., 2001. Relationships between physical activity and other health-related behaviors in a representative sample of U.S. college students. Am. J. Health Educ. 32, 83–88.

Ferreira, I., van der Horst, K., Wendel-Vos, W., Kremers, S., van Lenthe, F.J., Brug, J., 2006. Environmental correlates of physical activity in youth - a review and update. Obes. Rev. 8, 129–154.

Friedenreich, C.M., Orenstein, M.R., 2002. Physical activity and cancer prevention: etiologic evidence and biological mechanisms. J. Nutr. 132, 3456S–3464S.

Garcia-Cervantes, L., Rodriguez-Romo, G., Esteban-Cornejo, I., et al., 2015. Perceived environment in relation to objective and self-reported physical activity in Spanish youth. The UP&DOWN study. J. Sports Sci. 34, 1423–1429.

Goodwin, R.D., 2003. Association between physical activity and mental disorders among adults in the United States. Prev. Med. 36, 698–703.

Graham, D.J., Bauer, K.W., Friend, S., Barr-Anderson, D.J., Nuemark-Sztainer, D., 2014. Personal, behavioral, and socio-environmental correlates of physical activity among adolescent girls: cross-sectional and longitudinal associations. J. Phys. Act. Health 11, 51–61.

Grow, H.M., Saelens, B.E., Kerr, J., Durant, N.H., Norman, G.J., Sallis, J.F., 2008. Where are youth active? Roles of proximity, active transport, and built environment. Med. Sci. Sports Exerc. 40, 2071–2079.

Hallal, P.C., Andersen, L.B., Bull, F.C., Guthold, R., Haskell, W., Ekelund, U., 2012. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 380, 247–257.

Haug, E., Torsheim, T., Sallis, J.F., Samdal, O., 2010. The characteristics of the outdoor school environment associated with physical activity. Health Educ. Res. 25, 248–256.

Hobin, E.P., Leatherdale, S.T., Manske, S., Dubin, J.A., Elliott, S., Veugelers, P., 2012. A multilevel examination of gender differences in the association between features of the school environment and physical activity among a sample of grades 9 to 12 students in Ontario, Canada. BMC Public Health 12, 74.

Ishii, K., Shibata, A., Sato, M., Oka, K., 2014. Recess physical activity and perceived school environment among elementary school children. Int. J. Environ. Res. Public Health 11, 7195–7206.

Larsen, K., Gilliland, J., Hess, P., Tucker, P., Irwin, J., He, M., 2009. The influence of the physical environment and sociodemographic characteristics on children's mode of travel to and from school. Am. J. Public Health 99, 520–526.

Ledent, M., Cloes, M., Telama, R., Almond, L., Diniz, J., Piéron, M., 1997. Participation des jeunes européens aux activités physiques et sportives. Sports 61–71.

Lin, X., Zhang, X., Guo, J., et al., 2015. Effects of exercise training on cardiorespiratory fitness and biomarkers of cardiometabolic health: a systematic review and meta-analysis of randomized controlled trials. J. Am. Heart Assoc. 4.

Lohman, T., Roche, A., Martonell, R., 1988. Anthropometric Standardization Reference Manual. Human Kinetics Books, Champaign. Illinois.

McGrath, L.J., Hopkins, W.G., Hinckson, E.A., 2015. Associations of objectively measured built-environment attributes with youth moderate-vigorous physical activity: a systematic review and meta-analysis. Sports Med. 45, 841–865.

Moreira, L.D., Oliveira, M.L., Lirani-Galvão, A.P., Marin-Mio, R.V., Santos, R.N., Lazaretti-Castro, M., 2014. Physical exercise and osteoporosis: effects of different types of exercises on bone and physical function of postmenopausal women. Arq. Bras. Endocrinol. Metabol. 58, 514–522.

Mota, J., Esculcas, C., 2002. Leisure-time physical activity behavior: structured and unstructured choices according to sex, age, and level of physical activity. Int. J. Behav. Med. 9, 111–121.

Mota, J., Almeida, M., Santos, P., Ribeiro, J.C., 2005. Perceived neighborhood environments and physical activity in adolescents. Prev. Med. 41, 834–836.

Norman, G.J., Nutter, S.K., Ryan, S., Sallis, J.F., Calfas, K.J., Patrick, K., 2006. Community design and access to recreational facilities as correlates of adolescent physical activity and body-mass index. J. Phys. Act. Health 3, S118–S128.

Padilla, J., Wallace, J.P., Park, S., 2005. Accumulation of physical activity reduces blood pressure in pre- and hypertension. Med. Sci. Sports Exerc. 37, 1264–1275.

Patnode, C.D., Lytle, L.A., Erickson, D.J., Sirard, J.R., Barr-Anderson, D., Story, M., 2010. The relative influence of demographic, individual, social, and environmental factors on physical activity among boys and girls. Int. J. Behav. Nutr. Phys. Act. 7, 79.

Perales, F., del Pozo-Cruz, J., del Pozo-Cruz, J., del Pozo-Cruz, B., 2014. On the associations between physical activity and quality of life: findings from an Australian nationally representative panel survey. Qual. Life Res. 23, 1921–1933.

Sallis, J.F., Prochaska, J.J., Taylor, W.C., 2000. A review of correlates of physical activity of children and adolescents. Med. Sci. Sports Exerc. 32, 963–975.

Santos, M.P., Page, A.S., Cooper, A.R., Ribeiro, J.C., Mota, J., 2009. Perceptions of the built environment in relation to physical activity in Portuguese adolescents. Health Place 15, 548–552.

Sirard, J.R., Laska, M.N., Patnode, C.D., Farbakhsh, K., Lytle, L.A., 2010. Adolescent physical activity and screen time: associations with the physical home environment. Int. J. Behav. Nutr. Phys. Act. 7, 82.

Spittaels, H., Foster, C., Oppert, J.M., et al., 2009. Assessment of environmental correlates of physical activity: development of a European questionnaire. Int. J. Behav. Nutr. Phys. Act. 6, 39.

Spittaels, H., Verloigne, M., Gidlow, C., et al., 2010. Measuring physical activity-related environmental factors: reliability and predictive validity of the European environmental questionnaire ALPHA. Int. J. Behav. Nutr. Phys. Act. 7, 48.

Telama, R., Yang, X., Laakso, L., Viikari, J., 1997. Physical activity in childhood and adolescence as predictor of physical activity in young adulthood. Am. J. Prev. Med. 13, 317–323.

Van Hecke, L., Loyen, A., Verloigne, M., et al., 2016. Variation in population levels of physical activity in European children and adolescents according to cross-European studies: a systematic literature review within DEDIPAC. Int. J. Behav. Nutr. Phys. Act. 13, 70.

WHO, 2003. Health and Development Through Physical Activity and Sport. World Health Organization, Geneva.

W. M. A., 1989. Declaration of Helsinki, World Medical Association.