Longitudinal Associations between Adolescents' Environmental Perceptions and Sedentary Behavior, Physical Activity, Physical Fitness and Body Composition. The LabMed Physical Activity Study.

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Palavras-chave: ADOLESCENTS; ENVIRONMENT; SEDENTARY BEHAVIOR; PHYSICAL ACTIVITY; FITNESS; BODY COMPOSITION

“A man’s health can be judged by which he takes two at a time – pills or stairs”

Joan Welsh

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Resumo

Aumentar a atividade física, a aptidão física, diminuir o comportamento sedentário e manter uma composição corporal saudável parecem ser objetivos importantes quando se discute e analisa as determinantes da saúde em adolescentes. Estes comportamentos podem ser monitorizados até à vida adulta. Muitos estudos transversais apontam para o facto de que os fatores ambientais têm tido um papel fulcral nestes comportamentos. Contudo, pouco se sabe acerca do seu papel ao longo do tempo. Desta forma, o principal objetivo deste trabalho foi determinar as possíveis associações existentes entre as perceções ambientais e o comportamento sedentário, a atividade física, a aptidão física e a composição corporal ao longo de dois anos, em adolescentes Portugueses. Inicialmente, foi realizado um teste reteste do questionário ALPHA para avaliar as perceções ambientais e, à posteriori no estudo "LabMed Physical Activity Study", foram recolhidos dados relativos ao tempo passado em comportamento sedentário e atividade física através de acelerometria. A aptidão física foi avaliada de acordo com a bateria de testes ALPHA. Relativamente à composição corporal, o peso, altura, perímetro da cintura e percentagem de massa gorda foram medidos de acordos com protocolos e instrumentos estandardizados. A ANOVA de medidas repetidas foi realizada para perceber as diferenças intra e inter género ao longo do tempo. Modelos de regressão linear foram utilizados para estabelecer uma relação entre as variáveis ambientais no primeiro momento e o comportamento sedentário, atividade física, aptidão física e composição corporal após dois anos. Os principais resultados indicam-nos que (i) a fiabilidade do questionário ALPHA foi moderada a boa; (ii) melhores perceções em relação à segurança quanto ao crime no primeiro momento do estudo foram associadas com menor comportamento sedentário no segundo momento do estudo, em rapazes; (iii) menores perceções quanto ao contexto habitacional, nos rapazes, e maiores perceções de densidade residencial, nas raparigas, no primeiro momento do estudo foram negativamente associadas com a atividade física ligeira e atividade física moderada, respetivamente, no segundo momento do estudo; (iv) nos rapazes, perceções de maiores distâncias a instalações no primeiro momento do estudo foram associadas com menor aptidão cardiorrespiratória, força muscular e agilidade no segundo momento do estudo; (v) perceções positivas de disponibilidade de ciclovias e estética no primeiro momento do estudo foram associadas com melhor composição corporal no segundo momento do estudo, em raparigas.

Os resultados obtidos realçam a importância das perceções ambientais no estudo do comportamento sedentário, na atividade física, na aptidão física e na composição corporal durante a adolescência.

Palavras-chave: ADOLESCENTES; AMBIENTE; COMPORTAMENTO SEDENTÁRIO; ATIVIDADE FÍSICA; APTIDÃO FÍSICA; COMPOSIÇÃO CORPORAL.

Abstract

Increasing physical activity, physical fitness, decreasing sedentary behavior and maintaining a healthy weight status are important goals when one addresses adolescents' health. These behaviors may be tracked into adulthood. Several cross-sectional studies showed that environmental features have a key role in these behaviors. However, little is known about their associations over time. Thus, the main aim of this study was to determine the associations between environmental perceptions and sedentary behavior, physical activity, physical fitness and body composition over a two-year period, in adolescents. Initially, a test-retest of the ALPHA questionnaire was performed to assess environmental perceptions; and then this questionnaire was used in the school-based study "LabMed Physical Activity Study". Sedentary behavior and physical activity were measured with accelerometry. Physical fitness was assessed with the protocols of the ALPHA health-related fitness battery. For body composition, weight, height, waist circumference and percentage of body fat were measured according to standard instruments and protocols. One-way repeated measures ANOVA was used to access differences between and within-subjects over time. Linear regression models were fitted to determine the associations between environmental features at baseline and sedentary behavior, physical activity, physical fitness and body composition over a two-year period. The main findings of this thesis indicate that (i) the ALPHA questionnaire had moderate-to-good reliability; (ii) better crime safety perceptions at baseline were associated with lower sedentary behavior at follow-up, in boys; (iii) lower home environment perceptions, in boys, and higher residential density perceptions, in girls, at baseline were negatively associated with light physical activity and moderate physical activity, respectively, at follow-up; (iv) in boys, perceptions of higher distance to facilities at baseline were associated with lower cardiorespiratory fitness, muscular strength and agility at follow-up; (v) positive perceptions of bike lanes availability and aesthetics at baseline were associated with better body composition at follow-up, in girls.

The findings of this thesis highlight the importance of environmental perceptions in the study of sedentary behavior, physical activity, physical fitness and body composition in adolescents over time.

Keywords: ADOLESCENTS; ENVIRONMENT; SEDENTARY BEHAVIOR; PHYSICAL ACTIVITY; FITNESS; BODY COMPOSITION.

List of Abbreviations

ALPHA	Instruments for Assessing Levels of Physical Activity and Fitness
BF	Body Fat
BMI	Body Mass Index
CRF	Cardiorespiratory Fitness
EnRG	Environmental Research Framework for Weight Gain Prevention
LPA	Light Physical Activity
MPA	Moderate Physical Activity
MVPA	Moderate-to-Vigorous Physical Activity
PA	Physical Activity
PF	Physical Fitness
SB	Sedentary Behavior
VO_2 max	Maximum Oxygen Consumption
VPA	Vigorous Physical Activity
WC	Waist Circumference

Chapter 1

Introduction

Adolescents are one of the most sedentary population groups (Janssen et al., 2016; Matthews et al., 2008). The excess of sedentary behavior (SB) in adolescence is of concern since it can be a risk factor for obesity and other cardiovascular and metabolic complications (Carson et al., 2016). When entering adolescence, physical activity (PA) becomes less of a priority and is replaced with more sedentary behaviors (Hills et al., 2007). Increasing PA, decreasing SB and maintaining a healthy weight status are important goals to adolescents' health (Norman et al., 2010).

PA has several health benefits in youth (Janssen et al., 2010; Van Der Horst et al., 2007; WHO, 2010) and international recommendations stated that youngsters should engage in at least 60 minutes of daily moderate-to-vigorous PA (MVPA). Besides, it should include vigorous activities such as muscle and bone strength at least 3 times per week to achieve and maintain mental and physical health benefits and prevent non communicable diseases (WHO, 2010).

Despite the health benefits, the levels of PA are decreasing among worldwide population (WHO, 2010). In Portugal, only 31% of boys and 10% of girls engage at least 60 minutes of MVPA per day (Baptista et al., 2012). Attaining PA recommendations is of great importance since PA can be tracked from adolescence to adulthood (Telama et al., 2005).

Physical fitness (PF) is an important marker of health (Ortega et al., 2008) and a predictor of cardiovascular diseases and risk factors (Kaminsky et al., 2013; Lee et al., 2011). During adolescence, cardiorespiratory fitness (CRF) and muscular fitness are inversely associated with cardiovascular diseases risk factors (Ruiz et al., 2009b; Ruiz et al., 2008). In Portugal, only 61.1% of youth has adequate CRF levels (Santos et al., 2014b).

Another important cardiovascular diseases risk factor is obesity (McMurray et al., 2009). Unhealthy dietary patterns, low levels of PA and PF have been associated with the development of overweight and obesity in children and adolescents (Jimenez-Pavon et al., 2010; Ortega et al., 2008).

In this context, understanding which factors might increase and improve PA and PF, respectively, in youth is of great interest. PA, PF and body composition are influenced by several factors, including environmental features (Vanhelst et al., 2013). The perceptions that adolescents have of their surrounding environment may influence their movement behaviors and consequently their PF and body composition. Studies have shown that environmental features have been mostly associated with total PA in adolescents (Ding et al., 2011). There seems to be abundant cross-sectional data documenting the associations between environmental features and SB (Lowry et al., 2013; Machado-Rodrigues et al., 2014; Maitland et al., 2014; Veitch et al., 2013), different PA intensities (De Meester et al., 2013; Maddison et al., 2009), PF (Machado-Rodrigues et al., 2011; Machado-Rodrigues et al., 2012; Madsen et al., 2009; Vanhelst et al., 2013) and body composition (Duncan et al., 2012; Duncan et al., 2009; Lange et al., 2011; Machado-Rodrigues et al., 2012), in adolescents; however, little is known about what occurs longitudinally during the adolescence period.

In order to measure adolescents' environmental perceptions on large scale studies, valid and reliable questionnaires are necessary. There are several questionnaires to measure environmental perceptions in youth (Dunton et al., 2003; Durant et al., 2009; Evenson et al., 2006; Hume et al., 2006; Ommundsen et al., 2008; Rosenberg et al., 2009; Spittaels et al., 2010). From these, the ALPHA questionnaire has one of the most comprehensive set of environmental dimensions (Spittaels et al., 2010) and it was developed within the EU-funded project *Instruments for Assessing Levels of Physical Activity and Fitness* (ALPHA) to assess activity-friendly environmental features within the European countries (Spittaels et al., 2009; Spittaels et al., 2010). The ALPHA questionnaire was already tested and validated in adults (Spittaels et al., 2010) and Spanish adolescents (Garcia-Cervantes et al., 2014) however, the reliability of this questionnaire for Portuguese adolescents had not yet been assessed.

In this context we aimed to:

1. Determine the test-retest reliability of the long version of the ALPHA questionnaire for Portuguese adolescents.

Paper I - **Oliveira, A.**, Lopes, L., Abreu, S., Moreira, C., Silva, P., Mota, J., & Santos, R. Reliability of the ALPHA environmental questionnaire in Portuguese Adolescents. [submitted - *Archives of Exercise in Health & Disease*]

2. Examine if the environmental perceptions of Portuguese adolescents are associated with SB over a 2-year period.

Paper II - **Oliveira, A.**, Lopes, L., Abreu, S., Moreira, C., Silva, P., Agostinis-Sobrinho, C.; Oliveira-Santos, J., Mota, J., & Santos, R. Activity-friendly neighborhood perceptions and Sedentary Behavior in Adolescents: longitudinal results from the LabMed Physical Activity Study. [submitted – *Health & Place*]

3. Investigate if the environmental perceptions of Portuguese adolescents are associated with different PA intensities over a 2-year period.

Paper III - **Oliveira, A.**, Lopes, L., Abreu, S., Moreira, C., Silva, P., Mota, J., & Santos, R. Associations between Environmental perceptions and Physical Activity in Adolescents: longitudinal results from the LabMed Physical Activity Study. [submitted – *Journal of Physical Activity and Health*]

4. Determine if the environmental perceptions of Portuguese adolescents are associated with PF and body composition over a 2-year period.

Paper IV - **Oliveira, A.**, Lopes, L., Abreu, S., Moreira, C., Silva, P., Agostinis-Sobrinho, C.; Oliveira-Santos, J., Mota, J., & Santos, R. Environmental perceptions and its associations with Physical Fitness and Body Composition in

Adolescents: longitudinal results from the LabMed Physical Activity Study. [submitted – *Preventive Medicine*]

This thesis presents a theoretical background, the experimental work which includes the 4 papers, an overall discussion and the main conclusions.

Chapter 2

Theoretical Background

Sedentary Behavior, Physical Activity, Physical Fitness and Body Composition

Increasing physical activity (PA), decreasing the time spent in sedentary activities and maintaining a healthy weight status are important goals for adolescents' health (Norman et al., 2010).

The significance of too much sitting has been identified as an additional concern to the health consequences of insufficient PA (Zhu et al., 2017). Sedentary behavior (SB) is defined as any waking behavior that involves low energy expenditure (≤1.5 metabolic equivalents) while in a sitting, reclining or lying position (Tremblay et al., 2017). In general, girls are more likely to be classified as sedentary than boys (Byun et al., 2011; Ekelund et al., 2012; Gomes et al., 2014; Norman et al., 2010; Santos et al., 2005). Additionally, older girls are more likely to engage in sedentary activities than younger girls (Carson et al., 2013). When a child enters adolescence, PA and exercise become less of a priority and are replaced with other behaviors and interests (Hills et al., 2007). Data from several countries shows that adolescents spend a large time of their waking hours in sedentary activities (Colley et al., 2011; Matthews et al., 2008; Ruiz et al., 2011b; Santos et al., 2014a) and adolescents are one of the most sedentary population groups (Matthews et al., 2008). The excess of SB's in adolescents is a matter of concern since it can be an independent risk factor for obesity and cardiovascular and metabolic impairments (DeMattia et al., 2007; Ekelund et al., 2006; Mark et al., 2008). SB prevalence increases over time (Carson et al., 2013; Harding et al., 2015; Janssen et al., 2016; Lawman et al., 2014; Marks et al., 2015).

PA is defined as any bodily movement produced by skeletal muscles that require energy expenditure (Caspersen et al., 1985) and has important health benefits in youth (Janssen et al., 2010; Van Der Horst et al., 2007; WHO, 2010). Physically active adolescents have higher cardiorespiratory fitness (CRF) (Lubans et al., 2011; USDHHS, 2008; USDHHS, 2013), muscular fitness and

bone health (USDHHS, 2008; USDHHS, 2013), higher self-esteem and lower levels of anxiety, stress, obesity and other cardiovascular disease risk factors (Andersen et al., 2006; Ekelund et al., 2012; Poitras et al., 2016). A growing body of evidence also suggests that PA during childhood and adolescence can prevent cardiovascular diseases, osteoporosis, diabetes and obesity later in adulthood (Janssen et al., 2010; Strong et al., 2005).

PA is not easily measured and several methods have been studied over the years. Usually, methods for assessing PA levels rely on subjective and objective measures. The most common subjective methods to assess PA are questionnaires. Despite of the fact that questionnaires are inexpensive and can assess large populations at the same time (Vanhees et al., 2005), PA questionnaires rely on subjects recall and therefore are prompt to bias. Accelerometers are small monitors that assess objectively the duration and intensity of movement behaviors (sleep, SB and PA) over several days and therefore are very usual for movement research.

In order to improve cardiorespiratory and muscular fitness, bone health, cardiovascular and metabolic health, youth aged 5-17 years old should engage in at least 60 minutes of moderate-to-vigorous PA (MVPA) per day and most of this daily PA should be aerobic. Activities of vigorous intensities should be included such as muscle and bone strength at least 3 times per week (WHO, 2010).

Despite the health-related benefits of PA, the levels of PA are decreasing in many countries with several implications for the disease prevalence and general health among worldwide population (WHO, 2010). Most children and adolescents do not attain PA recommendations (Fakhouri et al., 2014; Serrano-Sanchez et al., 2011; Townsend et al., 2012). Data from Portuguese youth aged 10 to 17 years shows that boys had less sedentary time than girls (Baptista et al., 2012). Girls between 10-11 years had higher light physical activity (LPA) level than boys meanwhile, boys within the age of 16-17 years had higher LPA than girls. Still, 12-15 year old boys had higher LPA (Baptista et al., 2012). As for MVPA, boys spent more time in these activities than girls between 10-17 years old (Baptista et al., 2012).

The importance of youth attaining the recommended levels of PA relies not only on the PA health benefits but also because PA tracks from childhood to adolescence and from adolescence to adulthood (Telama et al., 2014; Telama et al., 2005).

In children and adolescents a great amount of activities occur outside the home and the school environment such as active transport or playing outside (de Vet et al., 2011).

In contrast with PA, physical fitness (PF) is a set of attributes that people have that enables them to perform physical activities (Caspersen et al., 1985) and is usually seen as having morphological, motor, cardiovascular and metabolic components (Shephard et al., 1994). PF is a key health marker (Ortega et al., 2008), as well as a morbidity and mortality predictor of cardiovascular diseases and all their causes (Kaminsky et al., 2013; Lee et al., 2011). Indeed, PF could be seen as part of or all body functions (musculoskeletal, cardiorespiratory, hematocirculatory, psycho neurological and endocrine-metabolic) involved in daily PA performance and/or exercise (Ortega et al., 2008). During childhood and adolescence CRF and muscular fitness are inversely associated with cardiovascular diseases risk factors (Ruiz et al., 2009b; Ruiz et al., 2008). PF levels in adults are limited by childhood and adolescence PF level (Hasselstrom et al., 2002). Traditionally, the health-related PF components are: CRF, muscular and abdominal strength, resistance, lower back flexibility and body composition (Malina et al., 1991).

PF can be measured in the laboratory or by field tests. In the laboratory, CRF is usually measured by a progressive test until exhaustion in a treadmill or cycle ergometer test while respiratory gases are collected (Eisenmann et al., 2002). In the field, the 20 meter shuttle run test is one of the most common methods for assessing CRF in youth, and has proven to be feasible, safe, valid and reliable in children and adolescents (Ruiz et al., 2011a).

The levels of PF in youth, over the last decades, have been decreasing and seemed to be inversely related to obesity prevalence (Eisenmann et al., 2002; Olds et al., 2006; Sandercock et al., 2010; Tomkinson et al., 2016; Tomkinson et al., 2007). However, recently, a study showed that maximum

oxygen consumption (VO_2max) rates in Danish adolescents did not change between 1983 and 2003, despite of body mass index (BMI) increased by 10% (Andersen et al., 2010). Moreover, in Portugal, 61.1% of youth (10-18 years) had adequate levels of CRF according to the FITNESSGRAM criteria for the 20m shuttle run test (Santos et al., 2014b).

A longitudinal study show that higher CRF levels in childhood and adolescence are associated to a healthier cardiovascular profile in adulthood (Ruiz et al., 2009a). The American Heart Association released, a few years ago, a set of seven cardiovascular health components for youth and adults in order to describe an ideal cardiovascular health such as smoking status, BMI, PA, healthy diet score, total cholesterol, blood pressure and glucose level (Lloyd-Jones et al., 2010). Literature has shown that children with higher cardiovascular health components have lower risk of developing hypertension, metabolic syndrome, high low-density lipoproteins cholesterol and triglycerides 21 years later in life (Laitinen et al., 2012). Increasing CRF lowers the risk of developing Type 2 Diabetes and it is associated with lower abdominal fat (Ortega et al., 2007).

Another important risk factor for cardiovascular diseases is obesity (McMurray et al., 2009). Childhood and adolescence obesity prevalence has been on the rise worldwide in the last decades; although, recent data show that there is no recent change in this prevalence (NCHS, 2015) and in some countries this prevalence is somewhat leveling off (Olds et al., 2011).

In epidemiological studies, body composition is usually measured by BMI, Waist Circumference (WC), skinfolds and percentage of Body Fat (BF) (Harmse et al., 2010).

BMI, as an index (weight/height^2), is easy to measure and it is a significant tool to monitor obesity prevalence (Santos et al., 2012). Nevertheless, BMI is not the best anthropometric marker of BF because it cannot distinguish fat from lean tissue or bone and may lead to misclassification (Santos et al., 2012). Also, BMI is not an appropriate method to measure BF distribution and has been suggested that it might be a less sensitive fat indicator than WC in children and adolescents (Brambilla et al., 2006).

WC is an effective and inexpensive anthropometric tool to measure abdominal adiposity and related metabolic risk factors in youth (Kelishadi et al., 2007; Lee et al., 2006). WC as an indicator of abdominal obesity has been included in the metabolic syndrome diagnosis (Bitsori et al., 2005; Bitsori et al., 2009; de Ferranti et al., 2004).

Measuring skinfold thickness is a simple, inexpensive and non-invasive method (Brannsether et al., 2013). Skinfold thickness estimates the subcutaneous fat and allows for quantification of BF percentage (Brambilla et al., 2006).

There are many other more accurate methods to measure BF, such as computed axial tomography or dual-energy X-ray absorptiometric densitometry; however, these techniques are not very easy to apply on large populations, are more complex and expensive (Santos et al., 2012).

It is crucial to understand the lifestyles that contribute to obesity development from adolescence transition period to adulthood. Existing data shows that lower levels of PA and unhealthy dietary patterns have been identified as classic risk factors for the development of overweight and obesity during childhood and adolescence (Jimenez-Pavon et al., 2010; Moreno et al., 2007). Even though youth have a low risk of death, an early and continued exposure to unhealthy lifestyles can increase the risk of premature mortality form cardiovascular diseases (Buchan et al., 2011). Moreover, a recent systematic review shows that, despite of the different methods to assess weight status, studies consistently show that cardiovascular and metabolic risk tracks from childhood and/or adolescence into adulthood (Camhi et al., 2010).

Ecologic Models and Environmental Features

The initiation and maintenance of regular PA seems to be of special significance during the transition from childhood to adolescence (Bergh et al., 2012). Therefore, rising PA levels among adolescents is seen as a public health priority. Reasons for this include the higher prevalence of insufficient PA in this

age group (Tenorio et al., 2010) as well as the associated health risks (Andersen et al., 2006; Janssen et al., 2010).

PA decrease during childhood and adolescence leads to interest in understanding the factors that influence active lifestyles in youth (Kahn et al., 2008).

Until several years ago, the study of youth's PA correlates focused mainly on individual factors such as attitudes towards PA (Ajzen, 1991) or self-efficacy, for example (Bandura, 1986). More recently, PA and PF have been considered to be influenced by several individual, interpersonal, social and environmental factors and their interactions (Bauman et al., 2012; Vanhelst et al., 2013).

Socio-ecological models such as the "Environmental Research Framework for Weight Gain Prevention" (EnRG) framework (Kremers et al., 2006) suggest that despite of individual factors, environmental factors (eg. parks and sports availability or recreational facilities) can influence PA levels. According to EnRG framework, the environmental effects on behavior can be mediated through individual's cognitions. Thus, the environment can influence behavior through factors like environmental perceptions, attitude towards PA and self-efficacy to engage in PA (Prins et al., 2011).

Additionally, the Ecological Model of Active Living was developed to identify possible political and environmental influences in four PA domains (household activities, occupational activities, active recreation and active transport) (Sallis et al., 2008). This model suggests there are multiple levels of influence for each domain, including intra-personal, perceived and built environment and policy factors. In this model, the perceived environment, including settings such as safety, aesthetics, comfort, access and convenience, and the built environment that includes access to settings and their characteristics, influences PA (Bauman et al., 2012; Sallis et al., 2006).

Activity-friendly environmental features have been abundantly studied over the past few years and therefore several questionnaires to measure these environmental characteristics in youth have been developed (Dunton et al., 2003; Durant et al., 2009; Evenson et al., 2006; Hume et al., 2006; Ommundsen

et al., 2008; Rosenberg et al., 2009; Spittaels et al., 2010). Of these, the ones that identify the most comprehensive set of environmental dimensions and features are the Neighborhood Environment Walkability Scale for Youth (Rosenberg et al., 2009) and the ALPHA questionnaire that derived from an EU-funded project entitled "*Instruments for Assessing Levels of Physical Activity and Fitness* (ALPHA)" that assesses activity-friendly environmental features within the European countries. (Spittaels et al., 2009; Spittaels et al., 2010). Two versions of the ALPHA questionnaire were developed: a long version containing 49 items, appropriate for research studies and a shorter version of 11 items, for surveillance and monitoring purposes. The ALPHA questionnaire covers several environmental features and have already been tested and validated in adults (Spittaels et al., 2010) and Spanish adolescents (Garcia-Cervantes et al., 2014).

Environmental variables have a key role modulating PA levels. Systematic reviews of the literature have shown that several environmental features are associated with adolescents' PA such as the recreation environment (parks and recreational facilities) (Ding et al., 2011; McGrath et al., 2015), neighborhood design (land-use mix, street connectivity and walkability) (Ding et al., 2011; McGrath et al., 2015), transportation environment (walking/biking facilities, traffic speed/volume, pedestrian safety structures and traffic safety) (Ding et al., 2011; McGrath et al., 2015) and social environment (crime-related safety and incivilities/disorders) (Ding et al., 2011). In fact, a perceived activity-friendly environment has been associated with the increased likelihood of youth attaining PA recommendations (Kopcakova et al., 2017).

It is well known that children and youth spend most of their time in school rather than anywhere else for the exception of their homes. Therefore schools play an important role in PA promotion (Pate et al., 2006). Indeed, children need safe settings where they can engage in active free-play and exercise (Veitch et al., 2006). The most common places for PA are school (90%), public parks (76%) and playing fields (74%) (Maddison et al., 2010). From a recent study it was possible to verify that from the 86 sites identified suited for PA, 23 were

parks and natural reserves (Rehrer et al., 2011). The beach near school was the most cited (37%) followed by a nearby park (33%) (Rehrer et al., 2011).

Environmental Features Associated with Sedentary Behavior, Physical Activity, Physical Fitness and Body Composition

Residential Area

In addition to the available open spaces to engage in PA, the area where adolescents live may also influence them to be more active. In fact, recently, one cross-sectional study with 6 243 Brazilian participants showed that rural adolescents had healthier habits (e.g. higher PA levels and less time sitting) than their urban peers (Regis et al., 2016). Further, despite limited information, youth from rural areas seem to have a higher likelihood of being classified as physically fit (Albarwani et al., 2009) and having more PF facilities (Powell et al., 2007) than their urban peers. In a Portuguese cross-sectional study with 362 adolescents (Machado-Rodrigues et al., 2011), the authors found that CRF was associated with the residential area in both genders. Rural adolescents had 76% more probability of being classified as fit comparing to those from urban areas; and boys from rural areas were 85% more likely to have normal weight than those from urban areas (Machado-Rodrigues et al., 2011). Other Portuguese cross-sectional studies also found that adolescents living in rural areas had higher CRF than their urban peers (Machado-Rodrigues et al., 2012; Machado-Rodrigues et al., 2014).

Adolescents inhabiting in urban neighborhoods engage significantly less in SBs than their rural peers (Machado-Rodrigues et al., 2014). Moreover, some Portuguese studies showed that rural boys had more time of LPA on weekdays nonetheless, urban boys had more time of MVPA on weekends (Machado-Rodrigues et al., 2012; Machado-Rodrigues et al., 2014). Both these studies also showed that urban girls had less time of LPA than their rural peers everyday and MVPA on weekends (Machado-Rodrigues et al., 2012; Machado-Rodrigues et al., 2014); however, one of these studies also showed that urban

girls had more time spent in sedentary activities than their rural peers during the weekdays (Machado-Rodrigues et al., 2012) while the other study found the opposite (Machado-Rodrigues et al., 2014). Nevertheless, youth living in rural areas are less likely to walk to school than those living in urban areas (Babey et al., 2009; Panter et al., 2010; Robertson-Wilson et al., 2008). Furthermore, data drawn from a national survey of approximately 650 000 Taiwanese adolescents showed that adolescent girls that attended rural schools had more BMI than those from urban schools (Lo et al., 2017) although, one cross-sectional study with a nationally representative sample of 8 573 participants from 28 regions across China has showed that there is a higher obesity prevalence in urban than rural schools (Li et al., 2016).

Recreational Facilities

Recreational facilities (play areas) can be private (provided by parents or around the house), public (communitarian sites and schools) and private-public (commercial area, school recess, playgrounds and open space parks) (Davison et al., 2006), The access (Ding et al., 2011; Yu et al., 2017) and proximity (Ding et al., 2011) of these types of facilities have been identified to promote PA. Facilities within a short distance have been associated with MVPA (Boone-Heinonen et al., 2010b; Cohen et al., 2006; D'Angelo et al., 2017; Markevych et al., 2016) and PF (Vanhelst et al., 2013). Additionally, cross-sectional analysis in a US large sample size (approximately 50 000) showed that youth that had a nearby recreational open space had a lower BMI comparing with those living further away (Duncan et al., 2014). The presence of recreational opportunities within 500m of youth's home has been inversely associated with BMI in a study with 1 048 participants from Canada (Gilliland et al., 2012). Moreover, an Australian cross-sectional study showed that youth with access to a healthy food outlet within 800m of their home had a 38% decreased risk of being overweight or obese comparing with their peers (Miller et al., 2014). On the other hand, US children (Duncan et al., 2014) and youth (Oreskovic et al., 2009) that inhabited in neighborhoods with lower recreational areas tend to had a

higher BMI. Further, a US study with 2 793 adolescents showed that a higher distance to facilities was associated with a higher BMI (Larson et al., 2013) although, another US study with 576 overweight and obese Hispanic youth showed that boys with a supermarket within 3km of their home had lower percentage of BF comparing with those without a supermarket (Hsieh et al., 2015). Nonetheless, no significant association was found between recreational open spaces and BMI in a US study with 1 034 adolescents (Duncan et al., 2012).

Owning sport equipment has been associated to lower SB levels (Lowry et al., 2013; Maddison et al., 2009; Salmon et al., 2013; Tandon et al., 2014). Data from the Trial of Activity for Adolescent Girls study showed that easy access to a recreational facility was related to a shorter distance and the access to a recreational facility seems to be associated with more MVPA time outside school in girls (Scott et al., 2007). A Canadian study with 811 participants also showed that youth are more physically active if their parents perceive to have a good access to recreational facilities in their neighborhood (Tucker et al., 2009). Likewise, the literature shows an association among environmental aesthetics and distance to sport facilities that was mediated by the adolescents' intent of being physically active in a study with 221 participants from the Netherlands (de Bruijn et al., 2006).

The presence of free or cheap recreational facilities was associated to the increased likelihood of being active in Portuguese adolescents (Santos et al., 2009). One US study among low-income, urban adolescent girls showed that fitness facilities usually lead to more minutes spent in MVPA (Hager et al., 2013). Data from cross-sectional Monitoring The Future surveys have showed that an additional PA outlet is positively associated with American students' engagement in vigorous exercise and sports (Slater et al., 2010). Still, one study with 9 268 adolescents from The California Endowment's Healthy Eating Active Communities program shows that enjoying physical education classes and using school facilities is significantly associated with better fitness (Madsen et al., 2009).

Sidewalks and Bike Lanes

The neighborhood design has several characteristics to consider such as houses, schools, companies, parks and sidewalks locations that can influence PA (Tester, 2009). Cross-sectional research has shown that the existence of sidewalks is positively associated to active transportation to school in American (Bungum et al., 2009) and Canadian (Gropp et al., 2012) youth.

A walking trail is defined by its existence, extension, proximity, quality or maintenance level, aesthetic characteristics and safety (Ball et al., 2006). In fact, the presence of sidewalks seems to be protective of pedestrian safety in a study with 928 American adolescents (aged 12-16 years) (Esteban-Cornejo et al., 2016). Additionally, sidewalks characteristics have been associated with LPA in American youth (Jago et al., 2006; Jago et al., 2005) in spite of one US cross-sectional study showing that sidewalks in good conditions were associated with a higher BMI in adolescents (Duncan et al., 2012).

Cross-sectional studies show that the availability of bike lanes is positively associated with PA in Brazilian adolescents (da Silva et al., 2017; de Farias Junior et al., 2011) however, girls perceived that riding in streets around their neighborhood was not safe due to traffic (de Farias Junior et al., 2011). The presence of bike paths has been negatively associated with the likelihood of being obese in a study with approximately 33 000 adolescents from the US (Slater et al., 2010). Furthermore, bike use or jog paths have been significantly associated with better CRF in American adolescents (Madsen et al., 2009).

Safety

Safety concerns and safety perceptions play a key role in how people respond to the built environment, with the fear of crime perception being a contributor to physical inactivity (Tester, 2009). Cross-sectional data shows that higher crime rates are associated with increased likelihood of being overweight in youth (Oreskovic et al., 2009). Road safety is a huge concern for parents and youth (Crawford et al., 2010). Parents' perception related to neighborhood

safety (eg. stranger danger or traffic concerns) can influence youth's PA (Hume et al., 2009). Parents concerns about road safety are justified for injuries that cause the largest part of worldwide deaths among youth aged 10-19 years old (WHO, 2008). Hurt children in accidents often are pedestrians or cyclists (WHO, 2008). For example, in the UK, parents' perception of unsafe roads was found to be negatively associated with children's walking and cycling (Hillman, 2006). Adolescents' low safety perceptions seem to have a negative effect on PA levels (especially in adolescent girls) (Slater et al., 2010). Indeed, perceived lack of safety perceived by adolescent girls was found to be a significant predictor of higher BMI in a study with a large sample from the US (Larson et al., 2013). Further, cross-sectional data with US adolescents reported that being rarely or never safe in their neighborhood had an increased risk of being overweight in comparison with those feeling sometimes or always safe (Duncan et al., 2009).

In general, boys' parents have a better safety perception comparing to girls' parents. In this line of thought, an Australian cross-sectional study with 347 adolescents and their parents found that boys' parents reported that it was safe for their sons to walk or cycle (Carver et al., 2005). Conversely, in another study, European adolescents that could use a safe route for walking or cycling had higher fitness levels comparing to those who could not (Vanhelst et al., 2013).

Comparing younger to older children, in an Australian study with 534 participants (188 children and 346 adolescents), it is possible to verify that parents of younger girls (8-9 years) have more concerns about road safety than parents of adolescents (13-15 years) (Carver et al., 2008). Children's parents are more concerned with strangers than vandals and parents of adolescent girls have more concerns regarding strangers than parents of adolescent boys (Carver et al., 2008). Therefore, US children that live in unsafe areas may spend less time in MVPA than their peers (Kurka et al., 2015). Neighborhood problematic behaviors such as young offenders, gang activities, and alcohol or drug abuse may also influence parents' perception, which can in turn influence indirectly adolescents' SB and PA (Kim et al., 2010).

Closely related to safety concerns during adolescence is independence. Having a dog provides more independency (Veitch et al., 2006) and, apparently, Australian adolescent girls take more often their dog for a walk if they go to places where they can be physically active (Carver et al., 2005). A recent US study with 925 participants shows that adolescents that walked their dog at least once a week engaged, on average, in more MVPA per day (Engelberg et al., 2016).

Whenever parents are questioned about what prevents their child to walk to school, the second most common feature is traffic danger (CDC, 2005). Parents' traffic concern is a barrier for children's active free-play opportunities (Veitch et al., 2006). Stranger danger and traffic have been identified as being negative to active travel to other locations (Rehrer et al., 2011). For example, a cross sectional study with a large sample (about 33 000) of 8th and 10th grade students from the US found that adolescents' higher traffic danger perception was negatively associated with PA levels (Slater et al., 2010). Conversely, in another cross-sectional study from Australia, the authors reported that adolescent boys and girls walked less for exercise in weekdays if their parents thought that there was too much traffic (Carver et al., 2005). Recent information shows that higher traffic perceptions were associated to being less active and having lower PF levels in a sample of 3 528 European adolescents (Vanhelst et al., 2013). However, one study with a large sample (n=3 440) of German adolescents aged 13 to 15 years has shown that traffic density was not associated with BMI (Lange et al., 2011). In Portugal, it was found a positive association between street connectivity and walking to school (Mota et al., 2007); conversely, in the US, higher road length was associated with less likelihood of engaging in MVPA in a longitudinal study with 293 adolescent girls (Rodriguez et al., 2012). Additionally, the increase of high-speed roads around schools is associated with a decrement in MVPA in youth from New Zealand (Oliver et al., 2015).

Parks

Natural environments seem to be more attractive than built environments (van den Berg et al., 2003) and when people were exposed to a natural environment several health benefits were documented over time such as lower negative emotions (anger and sadness) (Bowler et al., 2010). Thus, natural environments can encourage people to engage in healthy physical activities.

Parks have been identified as an important setting for youth to engage in PA (Ding et al., 2011; McGrath et al., 2015). Parks proximity from ones home has been shown to be associated to higher PA levels in youth (Ding et al., 2011; Mitchell et al., 2016; Rodriguez et al., 2012). The literature suggests that not only parks proximity is important to visit a park but also their features, conditions, aesthetics and safety (McCormack et al., 2010). Most parks have a set of features and equipment (sport fields and courts, playgrounds, open green spaces, among others) that provide several opportunities to engage in PA (Bedimo-Rung et al., 2005). For example, one study from Australia with 99 participants found that adolescents perceived that features such as swings, slides, no-smoking signs or table tennis tables motivated them to go to a park; and on the other hand, the existence of user rules and the presence of graffiti had the opposite effect (Veitch et al., 2016). Likewise, one US observational study that selected two neighborhood parks from each five cities, has also shown that larger parks contribute less to MVPA than smaller parks (Han et al., 2013). Moreover, a higher number of green spaces/parks was found to be associated to a lower likelihood of increased BMI, in a study of 3 831 youth's from the US (Bell et al., 2008). Further, it has been shown that overweight and obese Hispanic girls living in neighborhoods with a great amount of park space had lower percentage of BF than those with lower park space (Hsieh et al., 2015).

Park improvement may not result automatically on an increased use and/or increased PA levels. One US intervention study, with mostly, Latino and African-American in low-income neighborhoods showed that five parks were scheduled to have several improvements and each park was matched with a

comparison park with no plans to upgrade (Cohen et al., 2009). After the intervention, the average number of people observed in all parks decreased. Additionally, a 39% decline in park use and PA in all parks were assigned to the lower scheduled activities organization (Cohen et al., 2009). Nevertheless, park safety perceptions were higher in the intervention parks than in control parks (Cohen et al., 2009).

Results from a survey conducted in a rural town with 1 102 youth's from the US, aimed to assess the use of community parks and recreation spaces (Perry et al., 2011), showed that 88% of the participants went to a park at least once a month. On average, adolescents went once or 2-3 times per week and stayed among 20-60 minutes. Most reported activities were soccer, basketball and skateboard however, 63% and 42% of girls and boys, respectively, reported not being active during some time in the park (Perry et al., 2011). Even so, it was also found that the likelihood of using a park decreased if youth identified family as a motivator to engage in PA (Perry et al., 2011). Moreover, in an observational study assessing sixteen Michigan parks' usage, it was found that among all age groups, children and adolescents were the most seen in vigorous activities (Reed et al., 2012). Access to a safe park lead to regular PA in a study with 4 010 US adolescents (Babey et al., 2008) however, one study with a smaller sample size (n= 42 participants) from the UK showed that parks were not used to engage in PA (Lake et al., 2013).

Weather

Weather is an environmental characteristic that has not received much attention from researchers (Borrestad et al., 2011) due to the fact that seasonality cannot be changed.

Seasonal factors, such as temperature differences, precipitation and sunlight exposition are reported barriers of PA, capable of influencing negatively adolescents' participation in PA (Silva et al., 2011). However, in Northern European countries, there is a great tradition of being outside even during winter, and possible issues related to active transportation have been attributed

to the poor snow removal and lack of bike lanes than the winter per se (Borrestad et al., 2011). Plus, during snow days, in a study with 96 participants from the US, youth increase their PA in playgrounds and parks comparing to other locations or climacteric conditions (Oreskovic et al., 2015).

Generally, PA levels are higher in Spring and Summer and lower in the Winter (Belanger et al., 2009; Tucker et al., 2007). A recent German youth's longitudinal study showed that from Summer to Winter, exercise time diminished as well as VO_2max (Muller et al., 2013). In a Portuguese study, with 387 participants, it was reported that adolescent girls engaged in more sedentary activities than boys in June (Summer); whereas boys engaged more MVPA than girls in January (Winter) (Silva et al., 2013).

Chapter 3

Experimental Work

A full description of the methods, procedures and measures used in the papers included in this thesis can be seen in each of the papers. Briefly, data for the present work derived mostly from the “Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical activity (LabMed Physical Activity Study).

Regarding the first paper, participants were recruited from one school in the North Region of Portugal between September and October of 2011. The test-retest of the ALPHA questionnaire was performed with a 7-day interval for reliability intentions. Participants completed the questionnaire, in a physical education classroom in the presence of a researcher and their physical education teacher.

The remaining three papers are part of the “Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical activity (LabMed Physical Activity Study)”, a school-based cohort study carried out in 5 Portuguese cities from the North of Portugal aimed to evaluate the independent and combined associations of dietary intake and fitness levels on blood pressure.

The schools that were selected had already collaboration agreements established with our research centre and therefore were selected primarily for pragmatic, budgetary and logistical reasons.

Study recruitment was conducted at the participating schools. All students enrolled in the 7^{th} and 10^{th} grade classes were invited to participate in the study (n=1678). The power calculation for this study was based on the exposure of combined healthy diet and physical activity pattern with a prevalence of 14% (Huh et al., 2011). A sample of 754 participants would provide 80% power to detect 15% difference between exposed and unexposed at 5% significance. Taking into account an expected dropout rate of around 20% at each time-point, the sample size increased to 1086. However, to avoid discrimination all students enrolled in the participating school that provided consent participated in the study. Therefore, baseline data was collected in 2011 for 1,229

adolescents from the 7th and 10th grade; 1,011 and 789 subjects were reevaluated 1 and 2 years later, respectively.

The protocols of the studies presented on this PhD thesis were conducted in accordance with the World Medical Association's Helsinki Declaration for Human Studies (WMA, 1989). The Portuguese Data Protection Authority (#1112434/2011), the Portuguese Ministry of Science and Education (0246200001/2011) and Faculty of Sport, University of Porto, approved the study. All participants in these studies were informed of the study's goals, and written informed consent was obtained from participating adolescents and their parents or guardians.

Data collection for all variables was conducted during physical education classes by trained data collectors.

Table 1 shows the summary of the variables included in each paper of this thesis.

Table 1 – Papers' characteristics summary

Papers	Sample Size	Age	Main Variables of Interest	Covariates
I – Reliability of the ALPHA environmental questionnaire in Portuguese Adolescents	178 (89 girls)	12-16 years	ALPHA environment questionnaire	-
II – Environmental Perceptions and Sedentary Behavior in Portuguese Adolescents: Longitudinal results from the LabMed Physical Activity Study	221 (125 girls)	12-18 years	ALPHA environment questionnaire Sedentary behavior (accelerometers)	Age, body mass index socioeconomic status, baseline sedentary behavior, accelerometer wear time follow-up;
III – Associations between Environmental perceptions and Physical Activity in Portuguese Adolescents: longitudinal results from the LabMed Physical Activity Study	221 (125 girls)	12-18 years	ALPHA environment questionnaire Light physical activity, moderate physical activity, moderate-to-vigorous physical activity, vigorous physical activity (accelerometers)	Age, gender, socioeconomic status, body mass index, physical activity intensities, accelerometer wear time follow-up
IV – Environmental perceptions and its associations with Physical Fitness and Body Composition in Portuguese Adolescents: longitudinal results from the LabMed Physical Activity Study	583 (299 girls)	12-18 years	ALPHA environment questionnaire 20 meter shuttle run test, handgrip, long jump, agility 4x10m shuttle run test, body mass index, waist circumference, body fat percentage	Physical fitness models - age, gender, socioeconomic status, physical fitness, body mass index Body composition models – age, gender, socioeconomic status, body mass index, waist circumference, body fat

Paper I

Oliveira, A., Lopes, L., Abreu, S., Moreira, C., Silva, P., Mota, J., & Santos, R. **Reliability of the ALPHA environmental questionnaire in Portuguese Adolescents. [submitted]**

Reliability of the ALPHA environmental questionnaire in Portuguese adolescents

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Abstract

Background: There are several questionnaires to assess activity-friendly environmental features however; most of them do not cover as many environmental dimensions as needed. This paper assesses test-retest reliability for ALPHA environmental questionnaire for Portuguese adolescents.

Methods: The sample from this study comprised 178 participants (89 girls). The test-retest procedure was performed with a 7-day interval. Intraclass Correlation Coefficients (ICC), proportion of agreement and Cohen's Kappa were computed to assess the stability between the two test scores.

Results: Three of the nine dimensions showed good reliability, ICC's ranged from 0.55 to 0.80 (Distance to Local Services, Home Environment and Study Environment) with the remaining dimensions showing moderate reliability. Cohen's Kappa showed a fair to moderate strength of agreement in 43 of the 49 items of the questionnaire. The dimensions Home Environment and Study Environment had a high proportion of agreement.

Conclusion: The ALPHA questionnaire is a reliable instrument to assess perceptions of activity-friendly environmental features in Portuguese adolescents.

Keywords: Environment, Test-retest, Youth

Introduction

In the past few years there has been a growing body of evidence regarding environmental features associated with Physical Activity (PA) in adults, children and youth (Ding et al., 2011; Oliveira et al., 2014; Van Holle et al., 2012).

Some environmental features such as neighborhood design (Holt et al., 2008; Kerr et al., 2007), road safety (Hume et al., 2009), street connectivity (Mota et al., 2007), presence of sidewalks (Bungum et al., 2009), distance to school (Schlossberg et al., 2006), accessibility of recreational facilities (Boone-Heinonen et al., 2010; Giles-Corti et al., 2009; Santos et al., 2009) and parks (Babey et al., 2008; Perry et al., 2011), have been positively related to children's and adolescents' PA.

The perceptions that people have of their environment may influence their behavior. In order to measure these perceptions on large scale studies valid and reliable questionnaires are therefore necessary.

There are several questionnaires to measure perceptions of activity-friendly environmental features in youth (Dunton et al., 2003; Durant et al., 2009; Evenson et al., 2006; Hume et al., 2006; Ommundsen et al., 2008; Rosenberg et al., 2009; Spittaels et al., 2010). From these, the ones that identify the most comprehensive set of environmental dimensions and features are the Neighborhood Environment Walkability Scale for Youth (Rosenberg et al., 2009) and the ALPHA questionnaire (Spittaels et al., 2010). The ALPHA questionnaire was developed within the EU-funded project *Instruments for Assessing Levels of Physical Activity and Fitness* (ALPHA) to assess activity-friendly environmental features within the European countries (Spittaels et al., 2009; Spittaels et al., 2010). There were developed two versions of the ALPHA questionnaire: a long version containing 49 items, appropriate for research studies and a shorter version of 11 items, for surveillance and monitoring purposes.

The ALPHA questionnaire covers several environmental features and has already been tested and validated in adults (Spittaels et al., 2010). The aim

of this study was to determine the test-retest reliability of the long version of the ALPHA questionnaire for Portuguese adolescents.

Methods

Sample Design

Participants in this study (178, 89 girls) aged between 12 to 16 years were recruited from one school in the North Region of Portugal between September and October of 2011. The protocol was conducted in accordance with the World Medical Association's Helsinki Declaration for Human Studies (WMA, 1989). The Portuguese Data Protection Authority (#1112434/2011), the Portuguese Ministry of Science and Education (0246200001/2011) and Faculty of Sport, University of Porto, approved the study. All participants in this study were informed of the study's goals, and written informed consent was obtained from participating adolescents and their parents or guardians.

Procedures

The test-retest of the ALPHA questionnaire was performed with a 7-day interval for reliability intentions. Participants completed the questionnaire, in a physical education classroom in the presence of a researcher and their physical education teacher.

Measures

The long version of the ALPHA questionnaire (Spittaels et al., 2009; Spittaels et al., 2010) assesses (i) Types of Residences in the Neighborhood, (ii) Distance to Local Facilities, (iii) Walking and Cycling Infrastructures in the Neighborhood, (iv) Maintenance of Walking and Cycling Infrastructure in the Neighborhood, (v) Neighborhood Safety, (vi) How Pleasant is the Neighborhood for Walking or Cycling, (vii) Walking and Cycling Network, (viii) Home Environment and (ix) Study Environment.

Translation of the original questionnaire (English) to Portuguese was performed. Then, back translation was made from Portuguese to English, after solving pending divergences the final version of the questionnaire was presented.

Statistical Analysis

The scoring protocol for the ALPHA environmental questionnaire is described elsewhere (ALPHAProject, 2009). Thus, each dimension had their own questions – Types of Residences - detached houses, semi-detached houses and apartment buildings; Distance to Local Services - local shop, supermarket, local services, restaurant, fast-food or takeaway restaurant, bus stop, sport or leisure facilities and open recreation area; Total Infrastructure - presence of sidewalks, pedestrian zones or pedestrian trails, special lanes, routes or paths for cycling and cycling routes separated from traffic; Infrastructure Maintenance - sidewalks are well maintained, cycling paths are well maintained and play areas, playgrounds, parks or other spaces are well maintained; Residential Area Safety - dangerous to leave a bicycle locked, not enough safe places to cross busy streets, walking is dangerous because of the traffic, cycling is dangerous because of the traffic, dangerous during the day because of the level of crime and dangerous during the night because of the level of crime; Pleasant Aesthetics - pleasant environment for walking and cycling, generally free from litter or graffiti, trees along the streets and badly maintained, unoccupied or ugly buildings); Cycling and Walking Network Connectivity - many shortcuts for walking, cycling is quicker than driving during the day, many road junctions and many different routes for cycling or walking from place to place; Home Environment - bicycle, garden, small sports equipment, exercise equipment, phone and dog; Study Environment - escalators, stairs, fitness centre/equipment, bicycles provided by school, safe place to leave a bike, enough car parking spaces, showers and changing rooms, exercise classes, sports club and school subsidized public transports.

Answer frequencies mean scores for all the questions of the ALPHA environmental questionnaire were computed to assess differences between test and retest responses.

Intraclass Correlation Coefficients (ICC) was used to calculate the coefficient of stability of the scores on the two tests. The reference values of the ICC estimation were: > 0.75 was considered as good, between 0.50-0.75 as moderate and < 0.50 as poor reliability score (Portney et al., 2009). Proportion

of agreement was also computed to measure how many times adolescents gave the same score; a proportion of agreement above 0.70 was considered high (Fleiss, 1981).

Cohen's Kappa test was used to assess the intra-rater agreement between all the items and for each dimension of the ALPHA environmental questionnaire. The Cohen's Kappa value is a measure of the strength of agreement: $k < 0.20$ poor agreement; 0.21 to 0.40 fair agreement; 0.41 to 0.60 moderate agreement; 0.61 to 0.80 good agreement and 0.81 to 1 very good agreement (Altman, 1991).

All statistical analyses were performed using SPSS 21.0. The level of significance for all analyses was set at 0.05.

Results

The sample of this study comprised 178 participants (89 girls) aged 13.40±0.96 years.

Table 1 shows the answer frequencies mean scores of all 49 items of the ALPHA environmental questionnaire. Of those, seven had the same frequencies in the test and retest (Distance to Local Shops '21-30min', Distance to Local Services '1-5min', Distance to Sport and Leisure Facilities '11-20min', Distance to Open Recreation Areas '6-10min', Maintenance of Cycling Paths 'strongly agree', Pleasant Environment for Walking and Cycling 'strongly disagree' and Buildings Badly Maintained, Unoccupied or Ugly 'somewhat agree'). Regarding Distance to School, the mean score was identical between the test and retest indicating that adolescents have a good distance perception from home to school. Three of the nine dimensions showed good reliability (Distance to Local Services; Home Environment and Study Environment) with the remaining dimensions showing moderate reliability.

The table 2 describes ICC, Cohen's Kappa and proportion of agreement. For the whole sample, the dimension Connectivity had poor ICC and three dimensions (Distance to Local Services, Home Environment and Study Environment) had a good ICC. All other dimensions showed moderate ICCs. Overall, dimensions ICC's were better in girls than boys.

Concerning Cohen's Kappa, for the whole sample, 43 of the 49 items showed a fair to moderate strength of agreement. Values from boys and girls were very similar.

Home Environment and Study Environment were the only two dimensions that had a high proportion of agreement, including in all its items. Girls had identical results comparing with the total sample.

Table 1 –Answer frequencies mean scores, for all the questions of the ALPHA environmental questionnaire (test-retest)

Item/scale	None	A few	Some	Most	All	Mean±SD
1. Types of residences						
a) Detached houses	4.5 / 6.7	12.4 / 20.8	22.5 / 14.0	43.8 / 48.9	16.9 / 9.6	3.56±1.05 / 3.34±1.11
b) Semi-detached houses	22.5 / 17.4	33.1 / 38.2	33.7 / 34.8	7.9 / 8.4	2.8 / 1.1	2.35±1.00 / 2.38±0.91
c) Apartment buildings	56.7 / 52.8	21.9 / 27.0	13.5 / 11.8	5.1 / 7.3	2.8 / 1.1	1.75±1.05 / 1.77±1.00
	1-5 min	**6-10 min**	**11-20 min**	**21-30 min**	**>30 min**	**Mean±SD**
2. Distance to local services						
a) Local shop	42.1 / 58.4	34.8 / 30.3	12.9 / 5.6	3.4 / 3.4	6.7 / 2.2	1.98±1.14 / 1.61±0.91
b) Supermarket	20.8 / 29.2	18.0 / 26.4	27.5 / 21.3	13.5 / 10.7	20.2 / 12.4	2.94±1.40 / 2.51±1.34
c) Local services	6.2 / 6.2	14.6 / 20.8	24.2 / 27.5	12.9 / 20.2	42.1 / 25.3	3.70±1.31 / 3.38±1.24
d) Restaurant	43.3 / 49.4	29.8 / 32.0	12.9 / 10.1	7.9 / 6.7	6.2 / 1.7	2.04±1.20 / 1.79±1.00
e) Fast-food or takeaway restaurant	7.3 / 6.7	15.7 / 21.3	26.4 / 23.0	14.6 / 21.3	36.0 / 27.5	3.56±1.31 / 3.42±1.28
f) Bus stop	65.7 / 66.3	20.2 / 22.5	4.5 / 3.9	2.2 / 4.5	7.3 / 2.8	1.65±1.16 / 1.55±0.97
g) Sport or leisure facilities	14.6 / 19.7	26.4 / 24.2	23.6 / 23.6	11.8 / 14.0	23.6 / 18.5	3.03±1.39 / 2.88±1.38
h) open recreation area	23.6 / 24.7	28.7 / 28.7	14.6 / 19.7	16.3 / 12.9	16.9 / 14.0	2.74±1.42 / 2.63±1.36
	Strongly disagree	**Somewhat**	**Somewhat agree**	**Strongly agree**	**Does not apply**	**Mean±SD**
3. Total infrastructures						
a) Presence of sidewalks	18.0 / 7.3	11.8 / 19.7	32.0 / 44.4	38.2 / 28.7	- / -	2.90±1.10 / 2.94±0.88
b) Pedestrian zones or pedestrian trails	29.8 / 14.6	22.5 / 34.3	33.1 / 39.3	14.6 / 11.8	- / -	2.33±1.06 / 2.48±0.88
c) Special lanes, routes or paths for cycling	53.9 / 44.4	21.9 / 27.0	16.9 / 24.7	7.3 / 3.9	- / -	1.78±0.98 / 1.88±0.92
d) Cycling routes separated from traffic	57.3 / 10.1	20.8 / 21.3	15.2 / 42.1	6.7 / 23.0	- / -	1.71±0.96 / 1.88±0.92

	Strongly disagree	Somewhat	Somewhat agree	Strongly agree	Does not apply	Mean±SD
4. Infrastructure maintenance						
a) sidewalks are well maintained	19.1 / 10.1	15.7 / 21.3	35.4 / 42.1	23.6 / 23.0	6.2 / 3.4	2.82±1.18 / 2.88±0.99
b) cycling paths are well maintained	36.5 / 23.0	11.2 / 22.5	17.4 / 24.7	4.5 / 4.5	30.3 / 25.3	2.81±1.68 / 2.87±1.48
c) play areas, playgrounds, parks or other spaces are well maintained	15.7 / 10.1	16.3 / 21.9	24.7 / 38.2	27.0 / 20.2	16.3 / 9.6	3.12±1.30 / 2.97±1.10

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Mean±SD
5. Residential area safety					
a) dangerous to leave a bicycle locked	46.1 / 38.8	21.3 / 32.6	23.6 / 21.3	9.0 / 7.3	1.96±1.03 / 1.97±0.95
b) not enough safe places to cross busy streets	35.4 / 30.9	29.8 / 42.1	21.3 / 21.9	13.5 / 5.1	2.13±1.05 / 2.01±0.86
c) Walking is dangerous because of the traffic	54.5 / 40.4	26.4 / 42.1	13.5 / 14.6	5.6 / 2.8	1.70±0.91 / 1.80±0.79
d) Cycling is dangerous because of the traffic	52.2 / 35.4	32.0 / 43.8	10.7 / 17.4	5.1 / 3.4	1.69±0.86 / 1.89±0.81
e) dangerous during the day because of the level of	70.8 / 58.4	16.3 / 29.2	10.7 / 9.0	2.2 / 3.4	1.44±0.77 / 1.57±0.79
f) dangerous during the night because of the level of	58.4 / 48.9	25.3 / 29.2	10.1 / 16.9	6.2 / 5.1	1.64±0.90 / 1.78±0.90

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Mean±SD
6. Pleasant Aesthetics					
a) pleasant environment for walking and cycling	7.3 / 7.3	11.2 / 15.2	43.3 / 54.5	38.2 / 23.0	3.12±0.88 / 2.93±0.82
b) generally free from litter or graffiti	37.1 / 33.7	41.0 / 52.8	17.4 / 12.4	4.5 / 1.1	1.89±0.85 / 1.81±0.69
c) trees along the streets	7.3 / 6.7	22.5 / 24.7	28.7 / 37.6	41.6 / 30.9	3.04±0.97 / 2.93±0.91
d) badly maintained, unoccupied or ugly buildings	38.8 / 32.0	34.8 / 45.5	20.2 / 20.2	6.2 / 2.2	1.94±0.92 / 1.93±0.78

	Strongly disagree	Somewhat disagree	Somewhat agree	Strongly agree	Mean±SD
7. Cycling & walking network connectivity					
a) many shortcuts for walking	12.4 / 10.7	16.9 / 2.7	43.3 / 47.8	27.5 / 16.9	2.86±0.96 / 2.71±0.87
b) cycling is quicker than driving during the day	39.9 / 30.3	29.8 / 46.1	21.9 / 17.4	8.4 / 6.2	1.99±0.98 / 1.99±0.85
c) many road junctions	16.9 / 15.7	42.7 / 40.4	32.0 / 38.2	8.4 / 5.6	2.32±0.85 / 2.34±0.81

d) many different routes for cycling/walking from place to place	11.2 / 7.3	22.5 / 33.7	45.5 / 42.7	20.8 / 16.3	2.76±0.91 / 2.68±0.83

	Yes	**No**
8. Home environment		
a) Bicycle	88.8 / 89.3	11.2 / 10.7
b) Garden	73.6 / 75.8	26.4 / 24.2
c) Small sports equipment	83.7 / 79.8	16.3 / 20.2
d) Exercise equipment	47.8 / 48.9	52.2 / 51.1
e) Phone	80.3 / 77.0	19.7 / 23.0
f) Dog	58.4 / 57.9	41.6 / 42.1

9. Study environment	**Mean±SD Km**
9A. Distance to school	4.25±3.90 / 4.21±3.63

	Yes	**No**
9B. My school has..?		
a) Escalators	93.8 / 93.3	6.2 / 6.7
b) Stairs	98.3 / 94.9	1.7 / 5.1
c) Fitness centre/equipment	74.2 / 77.5	25.8 / 22.5
d) Bicycles provided by school	79.8 / 83.1	20.2 / 16.9
e) Safe place to leave a bike	79.8 / 80.9	20.2 / 19.1
f) Enough car parking spaces	82.6 / 80.9	17.4 / 19.1
g) Showers and changing rooms	95.5 / 96.1	4.5 / 3.9
h) Exercise classes	86.5 / 88.2	13.5 / 11.8
i) Sports club	83.7 / 80.9	16.3 / 19.1
j) School subsidized public transports	77.0 / 79.2	23.0 / 20.8

SD – Standard deviation.

Table 2 – Intraclass correlation coefficients (ICC) and 95% confidence intervals (CI), Cohen's kappa and proportions of agreement for all the questions of the ALPHA environmental questionnaire (test-retest)

	Total Sample			Boys			Girls		
	ICC (95% CI)	Cohen's Kappa	% Agreement	ICC (95% CI)	Cohen's Kappa	% Agreement	ICC (95% CI)	Cohen's Kappa	% Agreement
1. Residential density	0.73 (0.64, 0.80)			0.78 (0.67, 0.86)			0.69 (0.52, 0.80)		
a) Detached houses	0.66 (0.54, 0.74)	0.37*	55.1	0.68 (0.51, 0.79)	0.34*	50.5	0.61 (0.40, 0.74)	0.38*	59.6
b) Semi-detached houses	0.56 (0.41, 0.67)	0.23*	45.5	0.48 (0.21, 0.66)	0.16	40.4	0.64 (0.46, 0.77)	0.31*	50.4
c) Apartment buildings	0.76 (0.68, 0.82)	0.47*	66.8	0.79 (0.68, 0.86)	0.48*	67.5	0.74 (0.60, 0.83)	0.46*	66.2
2. Distance to local services	0.78 (0.71, 0.84)			0.77 (0.65, 0.85)			0.79 (0.68, 0.86)		
a) Local shop	0.55 (0.39, 0.66)	0.31*	55.7	0.56 (0.33, 0.71)	0.33*	57.3	0.53 (0.28, 0.69)	0.25*	53.8
b) Supermarket	0.82 (0.75, 0.86)	0.39*	51.8	0.85 (0.77, 0.90)	0.45*	57.4	0.79 (0.68, 0.86)	0.33*	46
c) Local services	0.68 (0.57, 0.76)	0.27*	43.8	0.61 (0.41, 0.74)	0.14	33.6	0.74 (0.60, 0.83)	0.39*	53.8
d) Restaurant	0.63 (0.50, 0.72)	0.18	45	0.66 (0.48, 0.77)	0.15	40.7	0.61 (0.41, 0.74)	0.21*	48.3
e) Fast-food or takeaway restaurant	0.61 (0.48, 0.71)	0.26*	43.3	0.50 (0.24, 0.67)	0.32*	47.2	0.70 (0.54, 0.80)	0.21*	39.3
f) Bus stop	0.50 (0.33, 0.63)	0.31*	64.5	0.40 (0.09, 0.61)	0.24*	59.5	0.61 (0.40, 0.74)	0.38*	69.6
g) Sport or leisure facilities	0.55 (0.40, 0.67)	0.28*	42.8	0.55 (0.31, 0.70)	0.19	29.9	0.55 (0.32, 0.71)	0.36*	49.5
h) open recreation area	0.63 (0.50, 0.73)	0.32*	46.6	0.53 (0.28, 0.69)	0.26*	43.9	0.69 (0.53, 0.80)	0.37*	49.4
3. Total infrastructure	0.58 (0.44, 0.69)			0.69 (0.53, 0.80)			0.48 (0.20, 0.66)		
Walking infrastructure	0.54 (0.38, 0.66)			0.67 (0.50, 0.79)			0.38 (0.05, 0.59)		
Cycling infrastructures	0.53 (0.37, 0.65)			0.55 (0.31, 0.70)			0.51 (0.25, 0.68)		
a) Presence of sidewalks	0.57 (0.42, 0.68)	0.28*	48.9	0.68 (0.51, 0.79)	0.39*	56.1	0.42 (0.11, 0.62)	0.17	41.6
b) Pedestrian zones or pedestrian trails	0.36 (0.14, 0.53)	0.22*	42.8	0.45 (0.16, 0.64)	0.27*	47.2	0.28(-0.10, 0.53)	0.17	38.2
c) Special lanes, routes or paths for cycling	0.47 (0.29, 0.61)	0.10	41	0.62 (0.42, 0.75)	0.12	41.6	0.31(-0.05, 0.55)	0.09	40.3
d) Cycling routes separated from traffic	0.35 (0.13, 0.52)	0.20*	48.3	0.15(-0.29, 0.44)	0.12	39.3	0.53 (0.28, 0.69)	0.29*	57.3

4. Maintenance	0.61 (0.47, 0.71)			0.54 (0.30, 0.70)			0.66 (0.48, 0.78)		
a) sidewalks are well maintained	0.58 (0.42, 0.68)	0.31*	48.9	0.53 (0.29, 0.69)	0.34*	50.5	0.62 (0.43, 0.75)	0.29*	47.2
b) cycling paths are well maintained	0.44 (0.25, 0.58)	0.18	37	0.40 (0.08, 0.60)	0.17	36	0.47 (0.19, 0.65)	0.18	38.2
c) play areas, playgrounds, parks or other	0.51 (0.35, 0.64)	0.26*	42.1	0.30 (0.08, 0.60)	0.19	37	0.66 (0.48, 0.77)	0.33*	33.1
5. Total safety	0.67 (0.56, 0.76)			0.65 (0.46, 0.77)			0.70 (0.54, 0.80)		
Safety from crime	0.65 (0.53, 0.74)			0.66 (0.49, 0.78)			0.63 (0.43, 0.76)		
Safety from traffic	0.64 (0.51, 0.73)			0.61 (0.41, 0.75)			0.66 (0.49, 0.78)		
a) dangerous to leave a bicycle locked	0.49 (0.31, 0.62)	0.23*	46.6	0.46 (0.18, 0.65)	0.19	42.6	0.51 (0.25, 0.68)	0.27*	50.5
b) not enough safe places to cross busy	0.43 (0.24, 0.58)	0.18	41.6	0.38 (0.05, 0.59)	0.18	41.5	0.48 (0.21, 0.66)	0.17	41.6
c) Walking is dangerous because of the	0.58 (0.44, 0.69)	0.24*	50.6	0.64 (0.45, 0.76)	0.33*	56.1	0.53 (0.29, 0.69)	0.14	44.8
d) Cycling is dangerous because of the	0.58 (0.43, 0.68)	0.25*	51.1	0.50 (0.23, 0.67)	0.26*	51.7	0.65 (0.47, 0.77)	0.25*	50.5
e) dangerous during the day because of the	0.56 (0.41, 0.68)	0.20*	51.9	0.61 (0.40, 0.74)	0.23*	55	0.47 (0.19, 0.65)	0.17	60.7
f) dangerous during the night because of the	0.60 (0.46, 0.70)	0.26*	53.9	0.56 (0.32, 0.71)	0.22*	51.7	0.64 (0.45, 0.76)	0.29*	56.2
6. Pleasure	0.66 (0.54, 0.74)			0.58 (0.36, 0.72)			0.71 (0.55, 0.81)		
Aesthetics	0.67 (0.56, 0.76)			0.61 (0.41, 0.75)			0.71 (0.56, 0.81)		
a) pleasant environment for walking and	0.40 (0.20, 0.56)	0.24*	50.5	0.24(-0.16, 0.50)	0.18	46	0.55 (0.31, 0.70)	0.31*	55
b) generally free from litter or graffiti	0.50 (0.33, 0.63)	0.27*	53.4	0.55 (0.32, 0.71)	0.27*	52.7	0.43 (0.14, 0.63)	0.26*	53.9
c) trees along the streets	0.62 (0.49, 0.72)	0.28*	49.4	0.45 (0.16, 0.64)	0.22*	44.9	0.75 (0.61, 0.83)	0.33*	53.9
d) badly maintained, unoccupied or ugly	0.58 (0.43, 0.69)	0.36*	56.8	0.52 (0.27, 0.69)	0.32*	52.8	0.64 (0.46, 0.77)	0.40*	60.7
7. Network	0.55 (0.39, 0.66)			0.58 (0.35, 0.72)			0.49 (0.22, 0.67)		
Connectivity	0.43 (0.24, 0.58)			0.51 (0.25, 0.68)			0.31(-0.05, 0.55)		
a) many shortcuts for walking	0.43 (0.23, 0.58)	0.22*	46	0.40 (0.09, 0.61)	0.23*	45	0.44 (0.15, 0.63)	0.20*	47.1
b) cycling is quicker than driving during the	0.48 (0.30, 0.58)	0.20*	44.4	0.55 (0.32, 0.71)	0.22*	46	0.40 (0.08, 0.60)	0.18	42.7
c) many road junctions	0.43 (0.24, 0.58)	0.22*	47.1	0.60 (0.39, 0.74)	0.26*	49.4	0.19(-0.23, 0.47)	0.17	44.9
d) many different routes for cycling or	0.36 (0.14, 0.52)	0.22*	46	0.37 (0.04, 0.59)	0.22*	45	0.35 (0.01, 0.57)	0.21*	47.1
8. Home environment	0.78 (0.70, 0.84)			0.70 (0.54, 0.80)			0.86 (0.78, 0.91)		
a) Bicycle	0.73 (0.63, 0.80)	0.57*	91.5	0.74 (0.60, 0.83)	0.59*	91	0.71 (0.55, 0.81)	0.55*	92.1
b) Garden	0.66 (0.55, 0.75)	0.50*	80.9	0.64 (0.44, 0.76)	0.47*	78.7	0.69 (0.53, 0.80)	0.53*	83.1
c) Small sports equipment	0.66 (0.55, 0.75)	0.49*	84.9	0.56 (0.32, 0.71)	0.38*	83.2	0.74 (0.60, 0.83)	0.58*	86.5

d) Exercise equipment	0.69 (0.59, 0.77)	0.53*	76.4	0.75 (0.62, 0.84)	0.60*	79.7	0.63 (0.44, 0.76)	0.46*	73
e) Phone	0.54 (0.38, 0.66)	0.37*	78.7	0.29(-0.09, 0.53)	0.17	67.4	0.77 (0.65, 0.85)	0.63*	89.9
f) Dog	0.86 (0.82, 0.90)	0.76*	88.2	0.85 (0.78, 0.90)	0.74*	87.6	0.87 (0.81, 0.92)	0.77*	88.8
9. Study environment	0.80 (0.73, 0.85)			0.84 (0.75, 0.89)			0.57 (0.34, 0.71)		
a) Escalators	0.47 (0.28, 0.60)	0.30*	91.5	0.55 (0.32, 0.71)	0.38*	88.8	-0.06(-0.61,0.31)	- 0.03	94.4
b) Stairs	0.66 (0.55, 0.75)	0.49*	96.6	0.66 (0.48, 0.78)	0.47*	93.3	1	1	100
c) Fitness centre/equipment	0.70 (0.60, 0.78)	0.54*	83.1	0.72 (0.58, 0.82)	0.57*	83.2	0.68 (0.51, 0.79)	0.51*	83.2
d) Bicycles provided by school	0.62 (0.48, 0.71)	0.44*	83.1	0.74 (0.61, 0.83)	0.59*	85.4	0.38 (0.06, 0.59)	0.23*	80.9
e) Safe place to leave a bike	0.70 (0.60, 0.78)	0.54*	85.4	0.68 (0.51, 0.79)	0.51*	79.8	0.67 (0.50, 0.78)	0.51*	91
f) Enough car parking spaces	0.63 (0.50, 0.72)	0.45*	83.7	0.62 (0.41, 0.75)	0.44*	80.9	0.63 (0.44, 0.76)	0.46*	86.6
g) Showers and changing rooms	0.54 (0.39, 0.66)	0.37*	95	0.63 (0.44, 0.76)	0.46*	93.3	-0.03(-0.57,0.32)	- 0.02	96.6
h) Exercise classes	0.54 (0.38, 0.65)	0.36*	85.9	0.60 (0.40, 0.74)	0.43*	85.4	0.41 (0.11, 0.61)	0.26*	86.5
i) Sports club	0.54 (0.38, 0.65)	0.36*	81.4	0.39 (0.07, 0.60)	0.24*	77.5	0.67 (0.50, 0.79)	0.50*	85.4
j) School subsidized public transports	0.78 (0.71, 0.84)	0.64*	87.6	0.78 (0.66, 0.85)	0.63*	85.4	0.78 (0.66, 0.85)	0.63*	89.9

* $p < 0.05$.

Discussion

We assessed test-retest reliability of the ALPHA environmental questionnaire for Portuguese adolescents. Overall, the questionnaire had moderate to good test-retest reliability (ICC's ranged from 0.55 to 0.80). Three of the nine dimensions showed good reliability (Distance to Local Services; Home Environment and Study Environment) with the remaining dimensions showing moderate reliability. Our results are supported by previous research. In adults, the long version of the ALPHA questionnaire also showed moderate to good reliability (ICC's ranged from 0.66 to 0.86) (Spittaels et al., 2010). Nevertheless, in that study the authors reported good test-retest reliability on five of the nine environmental dimensions (Spittaels et al., 2010). On an adapted version of the ALPHA questionnaire for Spanish youth, it was found moderate to good reliability (ICC's ranged from 0.42 to 0.77) (Garcia-Cervantes et al., 2014). Moderate to good reliability was also reported in other study using the Neighborhood Environment Walkability Scale for Youth evaluating adolescents and youth parents (Rosenberg et al., 2009). However, a survey assessing barriers to walking and cycling for youth showed fair to good reliability (ICC's ranged from 0.30 to 0.80) (Forman et al., 2008).

When considering each item, individually, we observed fair to very good ICC's (0.36-0.82). These results are slightly lower than reported by a study in adults (Spittaels et al., 2010) which showed a moderate to very good ICCs (0.44-0.82). In our study, the dimensions Distance to Local Services, Home Environment and Study Environment showed the highest ICCs and the dimensions involving Infrastructure, Network and Connectivity showed the lowest ICCs.

Overall, the proportion of agreement from our study ranged from 37 to 96.6%. Genderwise, girls (33.1-100%) had a higher proportion of agreement than boys (29.9-93.3%). The eighth and ninth dimensions (Home Environment and Study Environment) showed the highest proportion of agreement as also reported by other authors (Spittaels et al., 2010) for Home Environment and Work Environment. Comparing with different questionnaires, assessing similar

constructs, the values vary in adolescent girls (39-72%) (Evenson et al., 2006) and in children aged 10-12 years old (68-100%) (Hume et al., 2006).

In general, for most of the questions the strength of agreement was significant (Cohen's Kappa), although it ranged from 0.10 (poor) to 0.76 (good). As previously reported this discrepancy is higher in children (Hume et al., 2006). Notwithstanding, it is possible to see better results in a sample of adolescent girls (0.30-0.75) (Evenson et al., 2006) than the girls from this study (- 0.03-0.77), although they are different questionnaires and therefore direct comparisons cannot be performed.

Conclusion

The ALPHA questionnaire is a reliable instrument to assess perceptions of activity-friendly environmental features in Portuguese adolescents.

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Paper II

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Activity-friendly neighborhood perceptions and Sedentary Behavior in Adolescents: longitudinal results from the LabMed Physical Activity Study

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Abstract

Background: Little is known about how environmental perceptions of activity-friendly characteristics of the neighborhood associate with sedentary behavior over time, in adolescents. We aimed to examine if the environmental perceptions of activity-friendly characteristics of the neighborhood in Portuguese adolescents are associated with sedentary behavior over a 2-year period.

Methods: The sample comprised 221 participants (96 boys) aged 12-18 years from the LabMed Physical Activity Study. Sedentary behavior was assessed with accelerometry. The ALPHA questionnaire was used to evaluate adolescents' environmental perceptions. Linear regression analysis was performed to assess associations between environmental perceptions at baseline and sedentary behavior at follow-up, covariates included: age, socioeconomic status, sedentary behavior at baseline, body mass index at baseline and accelerometer wear time at follow-up (min/day).

Results: Sedentary behavior increased over time in boys. Boys' higher residential density (B= -0.186, p< 0.01), longer distances to local facilities (B= -0.027, p< 0.05) and better crime safety (B= -0.119, p= 0.02) perceptions, at baseline, were associated with lower sedentary behavior at follow-up, and better traffic safety (B= 0.102, p= 0.04) and lower home environment (B= 0.105, p= 0.04) perceptions at baseline were associated with higher sedentary behavior at follow-up, after adjustments. No significant results were found for girls.

Conclusions: Some activity-friendly characteristics of the neighborhood, such as distance to local facilities and crime safety were inversely associated with sedentary behavior at follow-up in boys but not in girls.

Keywords: Youth, Sedentary time, Accelerometry, Environment

Introduction

Sedentary behavior (SB) is defined as any waking behavior that involves energy expenditure of ≤ 1.5 METs while in a sitting, reclining or lying posture (Network, 2012). High levels of SB may be associated with increased body composition, metabolic syndrome and cardiovascular disease risk factors, lower academic achievement, fitness and self-esteem in youth (Carson et al., 2016; Tremblay et al., 2011). Moreover, SB seems to track from childhood into adulthood (Biddle et al., 2010). Hence, comprehending which features might change these behaviors it is of great importance.

Lately, ecological measures such as environmental features have been suggested as possibly having a direct impact on health behaviors (Sallis et al., 2008). Until recently, research focused mainly on the environmental features that may be associated with physical activity (PA) levels in youth (Ding et al., 2011; Oliveira et al., 2014). However, data on SB starts to emerge (Maitland et al., 2013; Stierlin et al., 2015). Safety concerns (Datar et al., 2013; Maitland et al., 2014; Veitch et al., 2013), green spaces/parks availability (Dadvand et al., 2014; Storgaard et al., 2013; Veitch et al., 2011), sport equipment availability at home (Lowry et al., 2013; Salmon et al., 2013; Tandon et al., 2014) and place of residence (urban versus rural) (Machado-Rodrigues et al., 2014; Salmon et al., 2013) are the most common features that have been associated with SB in youth.

For instance, unsafe neighborhoods were found to be associated to higher screen time in youth (Datar et al., 2013) while children that live in quiet streets tend to spend more time outside riding a bike instead of staying at home watching TV (Veitch et al., 2013). Furthermore, a large amount of green spaces around residential areas has been associated with lower overweight/obesity prevalence and screen time in children (Dadvand et al., 2014).

The majority of these studies have been cross-sectional in nature and, to the best of our knowledge, only one study was conducted between environmental perceptions and SB in adolescents longitudinally (Evenson et al., 2010). Given that data on SB is increasing, it is of public health interest to better understand whether environmental perceptions of activity-friendly

characteristics of the neighborhood affect SB over time. Thus, the aim of this study was to examine if the environmental perceptions of Portuguese adolescents are associated with SB over a 2-year period.

Methods

Study Design and Sampling

The current study is part of the "Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical Activity (LabMed Physical Activity Study)", a school-based cohort carried out in the North Region of Portugal. Data collection and sampling are described in more detail elsewhere (Agostinis-Sobrinho et al., 2016; Oliveira-Santos et al., 2016). Briefly, baseline data was collected in 2011 for 1,229 adolescents aged 12 to-14 years (7^{th} grade) and 15 to-18 years (10^{th} grade); 1,011 and 789 subjects were reevaluated 1 and 2 years later, respectively. Of those, 221 (125 girls) had complete data on the variables of interest for the present study at baseline and at second follow-up.

The protocol was conducted according to the World Medical Association's Helsinki Declaration for Human Studies (WMA, 1989). The Portuguese Data Protection Authority (#1112434/2011), the Portuguese Ministry of Science and Education (0246200001/2011) and Faculty of Sport, University of Porto, approved the study. All participants in this study were informed of the study's aims, and written informed consent was obtained from participating adolescents and their parents or guardians.

Measures

Anthropometric Measures

For weight and height measurements we used a digital scale (Tanita Inner Scan BC 532, Tokyo, Japan) and a portable stadiometer (Seca 213, Hamburg, Germany) respectively. All measurements were performed with participants in light clothing, without shoes, and according to standard procedures (Lohman et al., 1988). Body mass index (BMI) was calculated from the ratio of weight/height^2 (kg/m^2).

Sedentary Behavior

The accelerometer GT1M Actigraph (ActiGraph, Pensacola, Florida, USA) (Rothney et al., 2008; Silva et al., 2010) was used to obtain detailed and objective information about daily SB over five consecutive days (three

weekdays and two weekend days). The accelerometer was attached tightly in the hip, on the right side, with the notch faced upwards, and participants were instructed to use the accelerometer during waking hours and remove it during water-based activities; according to established procedures (Ward et al., 2005). The epoch length was set to 2 seconds to allow a more detailed estimate of PA intensity.

Participants had to have at least 8 hours of data to count as a valid day and to have at least three valid days to be included (two weekdays and one weekend day). The screening procedures were consistent with current accelerometry studies and also similar to the screening used in NHANES (Colley et al., 2010; Troiano et al., 2008). SB was identified using a cut-point of <100 counts.min^{-1}, as this cut-off was shown to have an excellent classification accuracy (Trost et al., 2011). SB was expressed as minutes per day (min/day).

Perceptions of Environmental Factors

Perceptions of environmental factors were assessed with the adapted version of ALPHA questionnaire (Spittaels et al., 2010). This questionnaire included questions on: types of residences in the neighborhood (3 items), distance to local facilities (8 items), walking and cycling infrastructure in the neighborhood (4 items), maintenance of walking and cycling infrastructure 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). From the total of 49 items, presented on the questionnaire, were created 15 environmental dimensions namely (1) residential density, (2) distance to local facilities, (3) total infrastructure, (4) cycling infrastructure, (5) walking infrastructure, (6) maintenance, (7) total safety, (8) safety from crime, (9) safety from traffic, (10) pleasure, (11) aesthetics, (12) cycling and walking network, (13) connectivity, (14) home environment and (15) workplace or study environment.

Socio-economic Status

Adolescents' socio-economic status (SES) was assessed with the Family Affluence Scale (Currie et al., 2008). This scale was developed specifically to measure children and adolescents SES in the context of the Health Behavior in School-Aged Children Study. The answers were summed and participants were classified as belonging to the Low SES (1st tertile of the FAS sum) Middle SES (2nd tertile) and High SES (Upper tertile).

Statistic Analysis

Descriptive data are presented as means and standard deviations. All variables were checked for normality. All variables (except SB) were transformed using natural algorithm given their skewed distribution. One-way repeated measures Analysis of Variance (ANOVA) was performed to access differences between and within-subjects over time.

Linear regression models were performed to determine the associations between SB at follow-up (as dependent variable) and environmental perceptions at baseline (as predictor variables) between genders. Model 1 was adjusted for age, SES, SB at baseline and accelerometer wear time at follow-up. Model 2 was further adjusted for BMI at baseline. Unstandardized regression coefficients were used to express the beta in the linear regression analysis.

Statistical analysis was performed using Statistical Package for the Social Sciences for Windows (Version 24.0 SPSS Inc., Chicago, IL). The level of significance for all analyses was set at 0.05.

Results

Variables descriptive characteristics are shown in Table 1. SB increased only in boys while BMI increased in both genders over time ($p< 0.05$).

Table 1 – Participants' characteristics of sedentary behavior and body mass index (means ± standard deviations)

	Total (n=221)		Girls (n=125)		Boys (n=96)	
	Baseline	**Follow-up**	**Baseline**	**Follow-up**	**Baseline**	**Follow-up**
Age (y)	13.63±1.47	15.63±1.47	13.90±1.50	15.90±1.50	13.29±1.36	15.29±1.36
SB (min/day)	673.73±97.83	678.69±111.64[a]	679.65±72.32	678.25±92.75	666.02±112.24	679.26±132.79
BMI (kg/m^2)	20.84±3.49	21.84±3.43[a]	21.13±3.50	22.23±3.47[b]	20.46±3.47	21.33±3.33

SB – Sedentary Behavior; BMI – Body Mass Index.

a - significantly different from total sample at baseline ($p<0.05$); b – significantly different from boys at follow-up ($p<0.05$).

Table 2 significant associations showed that girls perceived that facilities were within greater distance and had poorer study environmental perceptions in comparison with boys ($p<0.05$ for both).

Table 2 – Participants' characteristics of environmental dimensions at baseline (means ± standard deviations)

	Total (n=221)	Girls (n=125)	Boys (n=96)
Density	7.92±1.45	7.93±1.63	7.92±1.17
Distance	17.85±6.19	19.01±6.33[a]	16.33±5.69
Sidewalks	6.33±1.43	6.22±1.50	6.48±1.32
Bike Lanes	3.88±1.96	3.70±1.90	4.10±2.02
Maintenance	10.11±2.55	10.26±2.58	9.92±2.50
Crime Safety	10.27±1.74	10.30±1.62	10.24±1.89
Traffic Safety	10.30±1.86	10.24±1.80	10.39±1.95
Pleasure	12.92±1.78	13.03±1.79	12.77±1.76
Aesthetics	9.63±1.39	9.77±1.33	9.46±1.46
Network	10.16±2.20	10.20±2.25	10.10±2.15
Connectivity	8.20±1.71	8.22±1.75	8.17±1.65
Home Environment	7.37±1.54	7.26±1.50	7.51±1.58
Study Environment	12.05±1.45	12.24±1.38[a]	11.81±1.50

a – significantly different from boys at baseline ($p<0.05$);

In boys, higher residential density (B= -0.186, $p< 0.01$), longer distances to local facilities (B= -0.027, $p< 0.05$) and better crime safety (B= -0.119, p= 0.02) perceptions at baseline were associated with lower SB at follow-up, after adjustments for age, SES, SB at baseline and accelerometer wear time at follow-up (only significant results are shown in Table 3). No significant associations were found for girls (data not shown).

Table 3 – Longitudinal associations between environmental features at baseline and sedentary behavior at follow-up, in boys (Model 1)

	SB*		
	B	**95% CI**	**p**
Density	-0.186	-0.321 , -0.051	< 0.01
Distance	-0.027	-0.055 , 0.000	< 0.05
Crime Safety	-0.119	-0.216 , -0.023	0.02

SB – Sedentary Behavior; CI – Confidence Interval.

***** Adjusted for age, SES, SB at baseline and accelerometer wear time at follow-up.

However, when adding BMI at baseline as a covariate to the model, new associations were established. Similarly to model 1, higher residential density, longer distances to local facilities and better crime safety perceptions at baseline were associated with lower SB at follow-up ($p<0.05$ for all). Nonetheless, better traffic safety (B= 0.102, p= 0.04) and lower home environment (B= 0.105, p= 0.04) perceptions at baseline were associated with higher SB in boys at follow-up (only significant results are shown in Table 4). No significant associations between environmental perceptions at baseline and SB at follow-up were found for girls (data not shown).

Table 4 – Longitudinal associations between environmental features at baseline and sedentary behavior at follow-up, in boys (Model 2)

	SB*		
	B	**95% CI**	**p**
Density	-0.195	-0.331 , -0.059	< 0.01
Distance	-0.028	-0.056 , -0.001	0.04
Crime Safety	-0.118	-0.214 , -0.022	0.02
Traffic Safety	0.102	0.004 , 0.200	0.04
Home Environment	0.105	0.006 , 0.204	0.04

SB – Sedentary Behavior; CI – Confidence Interval.

***** Adjusted for age, SES, SB and BMI at baseline and accelerometer wear time at follow-up.

Discussion

This study sought to understand if Portuguese adolescents' activity-friendly environmental perceptions were associated with SB over time.

Longitudinal analysis from the first model showed that for boys, higher residential density, longer distances to local facilities and better crime safety perceptions at baseline, were associated with less SB at follow-up. These findings are particularly important from a public health perspective, since SB has been associated with several health complications (Carson et al., 2016; Tremblay et al., 2011). Indeed, it is known that, in youth, neighborhood characteristics might potentiate PA levels (Ding et al., 2011) or increase SBs (Stierlin et al., 2015). Possibly, safety perceptions that may come from friendship or by meeting their neighbors can influence positively youth environmental perceptions in a way that they would engage in more active behaviors (Mota et al., 2005; Rehrer et al., 2011). Commonly, youth that live in more activity-friendly neighborhoods have greater odds of being physically active; although, children that inhabit in more disadvantageous neighborhoods may also have relatively lower screen time levels and engage in regular PA (Hume et al., 2012).

Safety might be one of the environmental features that influences youth's SB the most. Poorer safety perceptions have been consistently associated with more SB in children (Brown et al., 2008; Datar et al., 2013). Conversely, studies often reveal that higher safety perceptions are associated with higher PA levels in youth (Carver et al., 2008; Echeverria et al., 2014; Oreskovic et al., 2014). Similarly, in spite of the use of different methods to measure environmental perceptions, we found that better crime safety perceptions were associated with less SB at follow-up. This is of great importance given that it can serve as basis for future interventions aiming to increase PA of young people by trying to reduce neighborhoods' crime rate.

Distance to facilities perceptions can also act as motivators to engage in PA (Babey et al., 2015; Hager et al., 2013). In fact, data suggests that nearby facilities may be a correlate of reduced SB (Babey et al., 2015) although, we did not find this. Instead, our findings indicate that distant facilities were associated

with a decrease on SB, and it is plausible that boys may not consider distance as a restriction to engage in regular PA. In addition, this association may raise the question that perhaps accessibility might be the issue for youth to engage in less active behaviors rather than distance to facilities per se. In fact, one intervention study has shown that, after building sidewalks, traffic signals and crosswalks, children's active trips to school increased (Boarnet et al., 2005) although, it has not been clarified whether the increase on active commuting is associated with less SB.

Our data also showed that, after including BMI on the regression analysis model (model 1), a better perception of traffic safety at baseline was associated with more time spent in SB at follow-up. This finding did not agree with previous data that has showed that high traffic is usually associated to less PA (Rehrer et al., 2011; Vanhelst et al., 2013). This may be due to the fact that as children enter adolescence, their interests change. These interests are, often, sedentary (Atkin et al., 2008; Biddle et al., 2009; Matthews et al., 2008) and therefore, environmental perceptions might not have as much influence on SB. Also, their autonomy grows (Viner et al., 2012) which may lead to the fact that many activities that adolescents undertake may occur outside their residential area.

Moreover, we had also found that boys who perceived having lower home environment perceptions at baseline had higher SB at follow-up. This is supported by previous research showing that having more sport equipment is associated with higher activity levels (Lowry et al., 2013; Maddison et al., 2009). Although these studies did not differentiate their findings by gender and despite the different study designs and measurements, all point to the fact that owning sport equipment is healthier for youth.

Additionally, our findings showed that girls' higher levels of SB at baseline were consistent with other studies using accelerometry (Matthews et al., 2008; Troiano et al., 2008), whereas the same did not happen at follow-up. Even though the tendency of SB is to increase in both genders over time (Biddle et al., 2010), our study revealed that girls maintained their SB level. Perhaps this can be explained by the fact that the initial level of time spent in SB was already too high for it to change significantly in comparison with boys.

Furthermore, we have found no associations between baseline environmental perceptions and SB at follow-up in girls. Interestingly, in one study (Evenson et al., 2010) the authors have also found no associations between adolescent girls' neighborhood perceptions and SB. Both studies indicated that maybe girls' environmental perceptions may have no impact on SB over time. More studies should be performed in this matter in favor of better comprehend how environmental perceptions associate with SB longwise, both in boys and girls.

This study has some limitations such as the small sample size and the fact that we did not examine the level of SES of the participants' area of residence however it can be addressed on future studies. The main strengths of this study include its longitudinal design, the objective measurement of adolescents´ SB and finally, the inclusion of several environmental features which gives key information to future health studies that aim to reduce SB in adolescents.

Conclusions

Some activity-friendly characteristics of the neighborhood, such as distance to local facilities and crime safety were inversely associated with SB at follow-up in boys, but not in girls. Future intervention studies aimed to reduce SB in youth should consider the potential role of activity-friendly environmental characteristics.

Conflicts of Interest

No conflicts of interest were reported by the authors of this paper.

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Paper III

Oliveira, A., Lopes, L., Abreu, S., Moreira, C., Silva, P., Mota, J., & Santos, R. **Associations between Environmental perceptions and Physical Activity in Adolescents: longitudinal results from the LabMed Physical Activity Study. [submitted]**

Associations between Environmental perceptions and Physical Activity in Adolescents: longitudinal results from the LabMed Physical Activity Study

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Abstract

Background: The aim of this study was to investigate if the environmental perceptions of Portuguese adolescents are associated with different physical activity intensities over a 2-year period.

Methods: This study included 221 participants (125 girls) aged 12-18 years from the LabMed Physical Activity Study. Physical activity was objectively measured with accelerometers and environmental perceptions were assessed with the ALPHA environmental questionnaire. One-way repeated measures Analysis Of Variance was performed to access differences between and within-subjects over time. Linear regression models were performed to determine the associations between environmental perceptions at baseline and physical activity at follow-up controlling for age, gender, socioeconomic status, body mass index, physical activity intensities at baseline and accelerometer wear time at follow-up (min/day).

Results: Overall, time spent in all different physical activity intensities decreased over the 2-year period. Higher residential density and lower home environment perceptions at baseline were associated with lower light physical activity at follow-up. Moreover, higher residential density and positive traffic safety perceptions at baseline were negatively associated with moderate physical activity at follow-up.

Conclusions: Some environmental attributes at baseline were associated with light physical activity and moderate physical activity at follow-up. No significant results were found for moderate-to-vigorous physical activity and vigorous physical activity.

Keywords: ALPHA, Accelerometer, Youth, Follow-up

Introduction

Low levels of physical activity (PA) have several implications on a person's health (WHO, 2010). Worldwide, many children and adolescents do not attain the international PA guidelines of at least 60min/day of moderate to vigorous PA (MVPA) (Ruiz et al., 2011). In Portugal, only 31% of boys and 10% of girls aged 10-18 years old engage in sufficient PA (Baptista et al., 2012).

To promote PA in adolescents, it is crucial to understand which determinants have a larger influence on this population. Recently, research has focused on the developed socio-ecological models as the "Environmental Research Framework for Weight Gain prevention" (EnRG). This model suggests that environmental factors such as the availability of recreation facilities and parks may influence PA levels (Kremers et al., 2006). In addition, other environmental features such as safety and traffic concerns (Bringolf-Isler et al., 2008; Hume et al., 2009), neighborhood connectivity (Sallis et al., 2009; Van Dyck et al., 2010), presence of sidewalks or bicycle lanes (D'Haese et al., 2011; de Farias Junior et al., 2011; Holt et al., 2008), distance to school (Nelson et al., 2008) and the weather (Bringolf-Isler et al., 2008; Harrison et al., 2011), have been consistently associated with PA in childhood and adolescence (Ding et al., 2011; Oliveira et al., 2014).

Despite this, evidence on this topic derives mostly from associations between environmental features and total PA in youth. Existing literature provides cross-sectional data on relationship between some environmental features and light PA (LPA) (Coombes et al., 2013; Jago et al., 2006; Jago et al., 2005; Lawman et al., 2014), moderate PA (MPA) (Coombes et al., 2013; Maddison et al., 2009), MVPA (Buck et al., 2015; De Meester et al., 2012; Kurka et al., 2015; Maddison et al., 2009; McGrath et al., 2016; Mitchell et al., 2016; Oliver et al., 2015; Oreskovic et al., 2014; van Loon et al., 2014) and vigorous PA (VPA) (Coombes et al., 2013) however, longitudinal associations are scarce and poorly understood (Oreskovic et al., 2015; Rodriguez et al., 2012).

Longitudinal studies would allow a better understanding how environmental perceptions can affect PA levels over time. To our knowledge,

the longitudinal studies conducted so far included mainly associations between the environment and MVPA and little is known about these environmental associations with other types of PA intensities (Rodriguez et al., 2012).

Thus, the aim of this study was to investigate if the environmental perceptions of Portuguese adolescents are associated with different PA intensities over a 2-year period.

Methods

Study Design and Sampling

The current study is part of the "Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical Activity (LabMed Physical Activity Study)", a school-based cohort carried out in the North Region of Portugal. Data collection and sampling are described in more detail elsewhere (Agostinis-Sobrinho et al., 2016). Briefly, baseline data was collected in 2011 for 1,229 adolescents aged 12 to-14 years (7^{th} grade) and 15 to-18 years (10^{th} grade); 1,011 and 789 subjects were reevaluated 1 and 2 years later, respectively. Of those, 221 (125 girls) had complete data on the variables of interest for the present study in year 1 and 3.

The protocol was conducted according to the World Medical Association's Helsinki Declaration for Human Studies (WMA, 1989). The Portuguese Data Protection Authority (#1112434/2011), the Portuguese Ministry of Science and Education (0246200001/2011) and Faculty of Sport, University of Porto, approved the study. All participants in this study were informed of the study's aims, and written informed consent was obtained from participating adolescents and their parents or guardians.

Measures

Anthropometric Measures

For weight and height measurements we used a digital scale (Tanita Inner Scan BC 532, Tokyo, Japan) and a portable stadiometer (Seca 213, Hamburg, Germany) respectively. All measurements were performed with participants in light clothing, without shoes, and according to standard procedures (Lohman et al., 1988). Body mass index (BMI) was calculated from the ratio of weight/height^2 (kg/m^2).

Physical Activity

The accelerometer GT1M Actigraph (ActiGraph, Pensacola, Florida, USA) (Rothney et al., 2008; Silva et al., 2010) was used to obtain detailed and objective information about daily PA over five consecutive days (three

weekdays and two weekend days). The accelerometer was attached tightly in the hip, on the right side, with the notch faced upwards, and participants were instructed to use the accelerometer during waking hours and remove it during water-based activities; according to established procedures (Ward et al., 2005). The epoch length was set to 2 seconds to allow a more detailed estimate of PA intensity.

Participants had to have at least 8 hours of data to count as a valid day and to have at least three valid days to be included (two weekdays and one weekend day). The screening procedures were consistent with current accelerometry studies and also similar to the screening used in NHANES (Colley et al., 2010; Troiano et al., 2008).

Perceptions of Environmental Factors

Perceptions of environmental factors were assessed with the adapted version of ALPHA questionnaire (Spittaels et al., 2010). This questionnaire included questions on: types of residences in the neighborhood (3 items), distance to local facilities (8 items), walking and cycling infrastructure in the neighborhood (4 items), maintenance of walking and cycling infrastructure 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). From the total of 49 items, presented on the questionnaire, were created 15 environmental dimensions namely (1) residential density, (2) distance to local facilities, (3) total infrastructure, (4) cycling infrastructure, (5) walking infrastructure, (6) maintenance, (7) total safety, (8) safety from crime, (9) safety from traffic, (10) pleasure, (11) aesthetics, (12) cycling and walking network, (13) connectivity, (14) home environment and (15) workplace or study environment.

Socio-economic Status

Adolescents' socio-economic status (SES) was assessed with the Family Affluence Scale (Currie et al., 2008). This scale was developed specifically to

measure children and adolescents SES in the context of the Health Behaviour in School-Aged Children Study. The answers were summed and participants were classified as belonging to the Low SES (1st tertile of the FAS sum) Middle SES (2nd tertile) and High SES (Upper tertile).

Statistic Analysis

Descriptive data are presented as means and standard deviations. All variables were checked for normality. All variables (except MVPA) were transformed using natural algorithm given their skewed distribution. One-way repeated measures Analysis Of Variance (ANOVA) was performed to access differences between and within-subjects over time.

Linear regression models were performed to determine the associations between PA intensities at follow-up (as dependent variables) and environmental perceptions at baseline (as predictor variables), adjusted for age, gender, SES, BMI, PA intensities at baseline and accelerometer wear time at follow-up. Unstandardized regression coefficients were used to express the beta in the linear regression analysis.

Statistical analysis was performed using Statistical Package for the Social Sciences for Windows (Version 21.0 SPSS Inc., Chicago, IL). The level of significance for all analyses was set at 0.05.

Results

Table 1 shows the general participants features. On average, all PA intensities decreased significantly over time ($p < 0.05$ per all). Boys had higher PA levels than girls at both time points ($p < 0.05$). Girls were significantly heavier than boys at follow-up ($p < 0.05$).

Table 1 – Participants' characteristics of physical activity intensities and body mass index (means ± standard deviations)

	Total (n=221)		Boys (n=96)		Girls (n=125)	
	Baseline	**Follow-up**	**Baseline**	**Follow-up**	**Baseline**	**Follow-up**
LPA (min/day)	110.07±29.4	93.30±26.01[c]	119.16±28.4	99.76±26.37	103.08±28.3	88.34±24.70[b]
MPA (min/day)	31.17±9.89	27.73±10.67[c]	34.31±9.69	29.71±11.51	28.76±9.39[a]	26.22±9.77[b]
MVPA (min/day)	54.50±19.23	48.24±19.91[c]	61.32±17.36	53.11±19.71	49.27±19.03[a]	44.50±19.32[b]
VPA (min/day)	23.33±12.55	20.51±12.83[c]	27.01±9.95	23.41±11.44	20.51±13.61[a]	18.28±13.43[b]
BMI (kg/m^2)	20.84±3.49	21.84±3.43[c]	20.46±3.47	21.33±3.33	21.13±3.50	22.23±3.47[b]

LPA – Light Physical Activity; MPA – Moderate Physical Activity; MVPA – Moderate-to-Vigorous Physical Activity; VPA – Vigorous Physical Activity; BMI – Body Mass Index;. a – significantly different from boys at baseline ($p<0.05$); b – significantly different from boys at follow-up ($p<0.05$); c - significantly different from total sample at baseline ($p<0.05$).

Girls had a higher perception that facilities were placed further away and that their study environment had less opportunities to engage in PA than boys (Table 2).

Table 2 – Participants' characteristics of environmental dimensions at baseline (means ± standard deviations)

	Total (n=221)	Boys (n=96)	Girls (n=125)
Density	7.92±1.45	7.92±1.17	7.93±1.63
Distance	17.85±6.19	16.33±5.69	19.01±6.33[a]
Sidewalks	6.33±1.43	6.48±1.32	6.22±1.50
Bike Lanes	3.88±1.96	4.10±2.02	3.70±1.90
Maintenance	10.11±2.55	9.92±2.50	10.26±2.58
Crime Safety	10.27±1.74	10.24±1.89	10.30±1.62
Traffic Safety	10.30±1.86	10.39±1.95	10.24±1.80
Pleasure	12.92±1.78	12.77±1.76	13.03±1.79
Aesthetics	9.63±1.39	9.46±1.46	9.77±1.33
Network	10.16±2.20	10.10±2.15	10.20±2.25
Connectivity	8.20±1.71	8.17±1.65	8.22±1.75
Home Environment	7.37±1.54	7.51±1.58	7.26±1.50
Study Environment	12.05±1.45	11.81±1.50	12.24±1.38[a]

a – significantly different from boys at baseline (p<0.05);

Table 3 shows the associations between environmental features at baseline and LPA at follow-up (only significant results are shown). Higher residential density in all participants (B= -0.116, p= 0.02) and lower home environment perceptions in boys (B= -0.126, p= 0.04) at baseline were associated with lower LPA at follow-up.

Table 3 – Longitudinal associations between environmental features at baseline and light physical activity at follow-up

	LPA*					
	Total			Boys		
	B	95% CI	p	B	95% CI	p
Density	-0.116	-0.198 - -0.035	0.01	-	-	-
Home	-	-	-	-0.126	-0.248 - -0.004	0.04

LPA – Light Physical Activity; 95% CI – 95% Confidence Interval.

* - Adjusted to age, gender, SES, BMI and LPA at baseline and accelerometer wear time at follow-up.

Associations between environmental features at baseline and MPA at follow-up can be seen in table 4 (only significant results are shown). Higher residential density in all participants (B= -0.087, p= 0.03) and in girls (B= -0.091, p= 0.04) at baseline were associated with lower MPA at follow-up. Positive traffic safety perceptions (B= -0.088, p= 0.02) at baseline were associated with lower MPA at follow-up in the whole sample. No significant results were found for MVPA and VPA.

Table 4 – Longitudinal associations between environmental features at baseline and moderate physical activity at follow-up

	MPA*					
	Total			Girls		
	B	95% CI	p	B	95% CI	p
Density	-0.087	-0.167 - -0.007	0.03	-0.091	-0.178 - -0.004	0.04
Traffic Safety	-0.088	-0.165 - -0.012	0.02	-	-	-

MPA – Moderate Physical Activity; 95% CI – 95% Confidence Interval.

* - Adjusted to age, gender, SES, BMI and MPA at baseline and accelerometer wear time at follow-up.

Discussion

This study presents data on physical activity intensities and environmental perceptions over a 2-year period in a sample of Portuguese adolescents.

We found inverse associations between residential density at baseline and LPA at follow-up. Regardless most research on environmental features and PA intensities focus specifically on MVPA, the time in LPA is of importance. Nowadays, youth inactive behaviors are high prevalent (Arundell et al., 2016) and the detrimental behaviors associated with these lifestyles are a source of concern. We believe that literature has been underestimating the value of LPA. Even though the low energy expenditure associated with LPA may not have physiological benefits as MVPA, engaging in these activities might have other advantages, i.e. social and psychological benefits, prevent sedentary behaviors and might lead youth to become more active with moderate or vigorous activities in the future. Indeed, for example, in San Diego, it was shown that parks' availability within a 50-meter buffer was associated with a 41% higher likelihood of engaging in LPA (Rodriguez et al., 2012). Other cross-sectional studies have also shown that sidewalk characteristics (Jago et al., 2006; Jago et al., 2005) and being around buildings or roads (Coombes et al., 2013) were positively associated to LPA. These findings might differ from ours, not only because those studies were conducted with a different population but also because the authors used different environmental dimensions such as buildings locations, domestic gardens or beaches (Coombes et al., 2013).

Additionally, higher residential density and traffic safety perceptions at baseline were negatively associated with MPA at follow-up. Contrary to our findings, literature has shown that lower traffic safety perceptions are associated with lower PA levels (Carver et al., 2009; Hume et al., 2009). This difference may be related to the fact that on these studies environmental perceptions were reported by parents (Hume et al., 2009) or objectively assessed (Carver et al., 2009), whereas we relied on adolescents' perceptions of their surrounding environments.

In our study no significant associations were found between environmental perceptions at baseline and MVPA and VPA at follow-up. Nevertheless, a previous longitudinal study has shown that a higher population density, the presence of schools and parks were associated to a higher likelihood of engaging in MVPA within a 50-m buffer from home (Rodriguez et al., 2012).Yet, another study found that adolescents had higher probability of spending time in MVPA on parks and playgrounds rather than staying at home (Oreskovic et al., 2015). Despite of the fact that our participants engaged in more MVPA/day than these two studies we did not find such associations between environmental features and MVPA. This may have happened due to different methodologies used to measure environmental features. While we assessed these features with adolescents' environmental perceptions, the other authors (Rodriguez et al., 2012;Oreskovic et al., 2015) applied objective measures.

Cross-sectional studies have also reported associations between environmental features and MVPA. Contrarily to what was found in our study, residential density was positively associated with MVPA in Nigerian adolescents (Oyeyemi et al., 2014). Regardless of using a similar environmental questionnaire than ours, the difference could have been due to their self-reported PA or our longitudinal design. Even so, some other studies have observed associations between MVPA and distance to local facilities. It is well known that distance to local facilities have an important role in how youth engage in PA (McGrath et al., 2016; Mitchell et al., 2016; van Loon et al., 2014). Nonetheless, one study did not find such associations (Prins et al., 2011). Even though these studies have similar methods and sample sizes, results may differ on the time that children wore the accelerometers. Despite of the fact that these studies have different epochs (15s (van Loon et al., 2014), 30s (McGrath et al., 2016; Mitchell et al., 2016) and 60s (Prins et al., 2011)), most of them (McGrath et al., 2016; Mitchell et al., 2016; van Loon et al., 2014) had similar daily recorded accelerometer data wear time (between 8-12h) whereas in the other study (Prins et al., 2011), the authors only counted time after school hours until

9 p.m. and on weekends which might have been the reason for the lack of associations between local facilities and PA.

On the other hand, safety also influences MVPA levels. To support this idea, a longitudinal study following adolescents into adulthood has shown that crime rate was associated to a decrement on MVPA levels (Boone-Heinonen et al., 2010). In children, additional pedestrian safety infrastructures were negatively associated with time spent engaging in MVPA (McGrath et al., 2016). Although this seems contradictory at first, there may be an explanation for it. Usually, when there is a higher concern for pedestrian safety it means that there is an increase on traffic volume. This might have contributed for parents to not allow their child to engage in PA. These restrictions on children's independent mobility are already documented in literature (Hume et al., 2009; Veitch et al., 2006).

Similarly to MVPA, research shows that PA facilities were positively associated with VPA (Coombes et al., 2013; Han et al., 2013; Heinrich et al., 2007). Although we cannot perform direct comparisons between different study designs, we can speculate that we did not find any results between VPA and environmental perceptions due to our longitudinal design. Although our study helps to better understand how environmental perceptions and PA intensities behave over time, our findings differed from the most of cross-sectional studies. This may have happened due to the decrease, on average, of PA and the use of different PA intensities instead of total PA.

Conclusions

Overall, time spent in all different PA intensities decreased over a 2-year period.

Higher residential density and lower home environment perceptions at baseline were associated with lower LPA at follow-up. Moreover, higher residential density and positive traffic safety perceptions at baseline were negatively associated with MPA at follow-up. No significant results were found for MVPA and VPA. Future studies addressing associations between environmental perceptions and PA should consider different PA intensities.

Limitations and Strengths

The inclusion of all PA intensities recorded by accelerometry and the longitudinal design represent the main strengths of this study. However, limitations must be acknowledged. The sample of this research was restricted to the North of Portugal and it was chosen by convenience instead of being randomly selected.

Conflicts of Interest

No conflicts of interest were reported by the authors of this paper.

Acknowledgments

AO performed the statistical analysis, interpreted the data and drafted the manuscript. LL reviewed the manuscript critically and provided statistical expertise. SA reviewed the manuscript critically and helped analyze the data. CM reviewed the manuscript critically. PS reviewed the manuscript critically and provided statistical expertise. JM reviewed the manuscript critically and helped analyze and interpret the data. RS selected the appropriate statistical methods, provided statistical expertise, helped analyze the data and reviewed the manuscript critically. All authors read and approved the final manuscript.

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Paper IV

Oliveira, A., Lopes, L., Abreu, S., Moreira, C., Silva, P., Agostinis-Sobrinho, C.; Oliveira-Santos, J., Mota, J., & Santos, R. **Environmental perceptions and its associations with Physical Fitness and Body Composition in Adolescents: longitudinal results from the LabMed Physical Activity Study. [submitted]**

Environmental perceptions and its associations with Physical Fitness and Body Composition in Adolescents: longitudinal results from the LabMed Physical Activity Study

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Abstract

Background: The environmental correlates have been extensively studied in the last years, but most associations with physical fitness and body composition have been cross-sectional in nature. This study aimed to determine if adolescents' environmental perceptions are associated with physical fitness and body composition in a 2-year follow-up.

Methods: Participants were 583 adolescents aged 12-18 years (299 girls) from the LabMed Physical Activity Study. Physical fitness and body composition were assessed with the protocols of the ALPHA health-related fitness battery and environmental perceptions with the ALPHA environmental questionnaire. Linear regression models were used to determine the associations between environmental perceptions at baseline and physical fitness and anthropometric measures at follow-up.

Results: Results showed that perceptions of distant facilities at baseline were associated with lower fitness at follow-up in boys. Positive perceptions of a pleasant environment at baseline were associated with better fitness at follow-up in boys. Also, boys' lower study environment perceptions at baseline were associated with higher body composition at follow-up. Additionally, girls' positive bike lanes availability and aesthetics perceptions at baseline were associated with better body composition at follow-up.

Conclusions: Positive environmental perceptions at baseline were associated with better physical fitness and body composition at follow-up.

Keywords: ALPHA, Fitness, Body Mass Index, Youth

Introduction

In children and adolescents, regular physical activity (PA) has many health benefits including improvements in body composition, muscular and cardiorespiratory fitness (USDHHS, 2008).

Despite of the health benefits, PA decreases from childhood to adolescence (Francis et al., 2013; Telama et al., 2014) with consequences for physical fitness (PF) and adiposity levels. For example, a 7-year longitudinal study has shown that a gradually diminished peak of VO2 from childhood to adolescence was accompanied by an increase on body mass index (BMI) (Bugge et al., 2013).

PA is determined by many factors (Bauman et al., 2012). The environmental correlates of PA have been extensively studied in the last years, but most of the research has been cross-sectional (Ding et al., 2011). Different lifestyles amongst adolescents and adults living in the same neighborhood may lead to different environmental perceptions (Van Dyck et al., 2013).

Some cross-sectional studies have shown associations between activity-friendly environmental features and body composition in youth (Duncan et al., 2012; Duncan et al., 2009; Gilliland et al., 2012; Hsieh et al., 2015; Lange et al., 2011; Machado-Rodrigues et al., 2012; Miller et al., 2014). In this regard, one study (Gilliland et al., 2012) found, in a sample of 1048 Canadian youth, that the presence of recreational opportunities within 500m of their home was negatively associated with BMI. Moreover, previous cross-sectional research has also shown associations between activity-friendly environmental features and PF in adolescents (Machado-Rodrigues et al., 2011; Machado-Rodrigues et al., 2012; Madsen et al., 2009; Vanhelst et al., 2013). For example, one of these studies showed that adolescents with nearby facilities (such as shops or gyms) had better PF (Vanhelst et al., 2013).

Some studies with Portuguese adolescents have also reported significant cross-sectional associations between activity-friendly environmental features and PA (Mota et al., 2011; Oliveira et al., 2014; Santos et al., 2009), obesity (Mota et al., 2009) and PF (Machado-Rodrigues et al., 2011) . However, little is

known about how changes in environmental perceptions associate with PF and adiposity over time in this population.

Thus, the aim of this study was to determine if the environmental perceptions of Portuguese adolescents are associated with PF and body composition over a 2-year period.

Methods

Study Design and Sampling

The current report is part of the "Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical Activity (LabMed Physical Activity Study)", a school-based study carried out in the North Region of Portugal. Data collection and sampling are described in detail elsewhere (Agostinis-Sobrinho et al., 2016). Briefly, baseline data was collected in 2011 for 1,229 adolescents aged 12 to-14 years (7^{th} grade) and 15 to-18 years (10^{th} grade); 1,011 and 789 subjects were reevaluated 1 and 2 years later, respectively. Of those, 583 (299 girls) aged 14.28±1.79 years had complete data on the variables of interest for the present report in year 1 and 3. For this study power analysis was calculated post hoc (for α =0.05) and it was higher than 0.8 for all multiple regression models for 583 subjects.

The LabMed Physical Activity Study protocol was conducted according to the World Medical Association's Helsinki Declaration for Human Studies (WMA, 1989). The Portuguese Data Protection Authority (#1112434/2011), the Portuguese Ministry of Science and Education (0246200001/2011) and Faculty of Sport, University of Porto, approved the study. All participants in this study were informed of the study's aims, and written informed consent was obtained from participants and their parents/legal guardians.

Measures

Anthropometric Measures

For weight and height measurements we used a digital scale (Tanita Inner Scan BC 532, Tokyo, Japan) and a portable stadiometer (Seca 213, Hamburg, Germany) respectively. All measurements were performed with participants in light clothing, without shoes, and in accordance with standard procedures (Lohman et al., 1988). BMI was calculated from the ratio of weight/height^2 (kg/m^2).

Waist circumference (WC) was taken in a standing position, to the nearest 0.1 cm, midway between the lower rib margin and the anterior superior iliac spine at the end of normal expiration (Lohman et al., 1988).

Percentage of body fat (BF) was estimated by bioimpedance (Tanita Inner Scan BC 532, Tokyo, Japan). Participants were asked to fast overnight for at least 10 hours. After the assessors manually introduced the age, sex and height into the scale system, the participants stood on the scale with light clothes and bared foot (Talma et al., 2013).

Physical Fitness

PF was assessed following the protocols of the ALPHA health-related fitness battery (Ruiz et al., 2011). The 20m shuttle run test evaluated cardiorespiratory fitness (CRF); handgrip strength and standing long jump measured muscular fitness; and, the 4×10m shuttle run test assessed motor fitness (speed and agility). A detailed description of each of these tests' protocols can be seen elsewhere (ALPHAProject, 2009).

Perceptions of Environmental Features

Perceptions of environmental features were assessed with the long version of ALPHA questionnaire (Spittaels et al., 2010). This questionnaire included questions on: types of residences in the neighborhood (3 items), distance to local facilities (8 items), walking and cycling infrastructure in the neighborhood (4 items), maintenance of walking and cycling infrastructure 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). From the total of 49 items, presented on the questionnaire, were created 15 environmental dimensions namely (1) residential density, (2) distance to local facilities, (3) total infrastructure, (4) cycling infrastructure, (5) walking infrastructure, (6) maintenance, (7) total safety, (8) safety from crime, (9) safety from traffic, (10) pleasure, (11) aesthetics, (12) cycling and walking network, (13) connectivity, (14) home environment and (15) workplace or study environment.

Socio-economic Status

Adolescents' socio-economic status (SES) was assessed with the Family Affluence Scale (Currie et al., 2008). The answers were summed and participants were classified as belonging to the Low SES (1st tertile of the FAS sum), Middle SES (2nd tertile) and High SES (Upper tertile).

Statistic Analysis

Descriptive data are presented as means and standard deviations. All variables were checked for normality. All variables were transformed using natural algorithm. One-way repeated measures ANOVA was performed to access differences between and within-subjects over time for PF and body composition variables.

Linear regression models were fitted to determine the associations between environmental perceptions at baseline (as predictor variables) and PF and body composition at follow-up (as the dependent variables). All models were adjusted for age, gender and SES. PF models were still adjusted for PF and BMI at baseline; for the body composition models were also used the BMI, WC and percentage of BF at baseline. Unstandardized regression coefficients were used to express the beta in the linear regression analysis.

Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences) for Windows (Version 21.0 SPSS Inc., Chicago, IL). Power analysis was calculated with G* Power (version 3.1.9.2, Dusseldorf, Germany). The level of significance for all analyses was set at 0.05.

Results

All participants' features are shown in Table 1. Boys had better CRF, agility and strength (handgrip and long jump tests) than girls at baseline and follow up. Boys had lower BMI at follow up and a higher WC at baseline and follow up, than girls. For percentage of BF, boys showed lower levels than girls at both time points. Table 1 also shows that in the 2-year follow-up it is possible to verify that handgrip, long jump and agility improved the most in boys and their BF percentage decreased over time.

Table 1 – Participants' characteristics of physical fitness and body composition (means ± standard deviations)

	Total (n=583)		Boys (n=284)		Girls (n=229)	
	Baseline	**Follow-up**	**Baseline**	**Follow-up**	**Baseline**	**Follow-up**
20mSRT (ml/kg/min)	43.77±24.22	53.33±28.10[d]	57.23±24.90	70.15±27.70	30.99±14.85[b]	37.35±16.97[c]
Handgrip (kg)	26.72±8.27	30.99±9.12[d]	30.67±9.33	37.17±8.71[a]	22.97±4.67[b]	25.12±4.42[c]
Long Jump (cm)	158.52±31.39	168.87±37.72[d]	174.82±30.67	195.06±29.20[a]	143.04±23.18[b]	144.00±26.35[c]
Agility 4x10m (s)	11.83±1.29	11.39±1.34[d]	11.22±1.12	10.58±1.02[a]	12.41±1.17[b]	12.17±1.13[c]
BMI (kg/m^2)	21.21±3.62	22.21±3.56[d]	21.03±3.52	21.90±3.44	21.39±3.71	22.50±3.65[c]
WC (cm)	72.85±9.69	75.96±9.53[d]	73.73±9.63	76.96±9.60	72.02±9.68[b]	75.00±9.37[c]
BF (%)	20.68±8.44	20.10±8.91[d]	15.70±6.82	13.73±5.71[a]	25.41±7.00[b]	26.14±6.99[c]

20mSRT – 20m shuttle run test; BMI – Body Mass Index; WC – Waist Circumference; BF – Body Fat percentage. a – significantly different between boys at baseline ($p<0.05$); b – significantly different from boys at baseline ($p<0.05$); c – significantly different from boys at follow-up ($p<0.05$); d - significantly different from total sample at baseline ($p<0.05$).

Girls had significantly higher environmental perceptions scores for the dimensions of distance to local facilities and maintenance than boys (Table 2).

Table 2 – Participants' characteristics of environmental dimensions at baseline (means ± standard deviations)

	Total (n=583)	Boys (n=284)	Girls (n=299)
Density	7.96±1.48	7.94±1.49	7.97±1.48
Distance	18.39±6.05	17.13±5.44	19.59±6.36[a]
Sidewalks	5.92±1.61	5.89±1.63	5.96±1.60
Bike Lanes	3.90±1.93	3.94±1.93	3.86±1.93
Maintenance	9.50±2.80	9.13±2.83	9.86±2.72[a]
Crime Safety	10.18±1.93	10.25±1.91	10.10±1.95
Traffic Safety	10.08±1.99	10.14±1.99	10.02±2.00
Pleasure	12.5±1.94	12.41±1.88	12.58±1.99
Aesthetics	9.31±1.54	9.26±1.49	9.35±1.60
Network	9.99±2.25	10.00±2.24	9.97±2.27
Connectivity	7.99±1.77	8.00±1.78	7.98±1.77
Home Environment	7.32±1.61	7.24±1.57	7.40±1.63
Study Environment	12.17±1.60	12.06±1.63	12.28±1.57

a – significantly different from boys at baseline ($p<0.05$).

Table 3 shows the associations between environmental dimensions and PF (only significant results are shown). Distance to local facilities at baseline was negatively associated with CRF at follow-up in all participants (B= -0.016, p< 0.01) and in boys (B = -0.032, p< 0.001), meaning that facilities within a longer distance were associated with lower CRF. Lower home environment perceptions at baseline were associated with higher CRF at follow-up in all participants (B= 0.040, p= 0.03). In boys, perceptions of distant facilities at baseline were positively associated with muscular strength on the handgrip test (B= 0.013, p= 0.01) at follow-up. Also, distance to facilities at baseline was negatively associated with muscular strength on the long jump (B= -0.023, p< 0.01) and agility (B= 0.027, p= 0.01) tests at follow-up. Additionally, those with a more pleasant neighborhood at baseline had higher agility at follow-up (B= -0.149, p< 0.05).

Table 3 – Longitudinal associations between environmental features at baseline and physical fitness at follow-up

	20m-SRT[*1]						Handgrip[*2]			Long Jump[*3]			Agility[*4]		
	Total			Boys			Girls			Boys			Boys		
	B	95% CI	p	B	95% CI	p	B	95% CI	p	B	95% CI	p	B	95% CI	p
Distance	-0.016	-0.027 - -0.006	< 0.01	-0.032	-0.049 - -0.016	< 0.001	0.013	0.003 – 0.023	0.01	-0.023	-0.041 – 0.006	< 0.01	0.027	0.006 – 0.047	0.01
Pleasure	-	-	-	-	-	-	-	-	-	-	-	-	-0.149	-0.295 - -0.003	< 0.05
Home Environment	0.040	0.004 – 0.077	0.03	-	-	-	-	-	-	-	-	-	-	-	-

20m-SRT – 20 meter shuttle run test; 95% CI – 95% Confidence Interval.

*[1] – Adjusted to age, gender, SES, 20m-SRT and BMI at baseline.

*[2] - Adjusted to age, gender, SES, handgrip and BMI at baseline.

*[3] - Adjusted to age, gender, SES, long jump and BMI at baseline.

*[4] -Adjusted to age, gender, SES, agility and BMI at baseline.

Associations between environmental dimensions and body composition are shown in Table 4 (only significant results are shown). The presence of bike lanes and positive aesthetics perceptions in girls were associated to a lower BMI (B= -0.049, p< 0.01; B= -0.148, p= 0.01) and WC (B= -0.057, p= 0.01; B= -0.223, p< 0.01), respectively although, positive perceptions of a pleasant neighborhood were associated with a higher BMI (B= 0.102, p= 0.03) and WC (B= 0.165, p< 0.01) in girls. The availability of bike lanes and better crime safety perceptions in boys were associated with a higher BMI (B= 0.049, p< 0.01; B= 0.043, p< 0.01) and WC (B= 0.047, p= 0.01; B= 0.053, p= 0.01), respectively. Nevertheless, WC was inversely associated with residential density in boys (B= -0.059, p= 0.01). Higher distance to local facilities (B= -0.013, p= 0.04), the presence of sidewalks (B= -0.074, p< 0.01), and a positive aesthetics perception (B= -0.180, p= 0.01) were associated with a lower percentage of BF in girls. However, a more pleasant neighborhood (B= 0.124, p= 0.03) was associated with a higher percentage of BF in girls. Facilities within longer distance (B= 0.019, p< 0.01), better crime safety (B= 0.070, p< 0.01) and lower study environment (B= 0.048, p= 0.04) perceptions at baseline were associated with a higher percentage of BF in boys at follow-up.

Table 4 – Longitudinal associations between environmental features at baseline and body composition at follow-up

	BMI*1						WC*2						BF*3					
	Boys			Girls			Boys			Girls			Boys			Girls		
	B	95% CI	p	B	95% CI	p	B	95% CI	p	B	95% CI	p	B	95% CI	p	B	95% CI	p
Density	-	-	-	-	-	-	-0.059	-0.103 – 0.014	0.01	-	-	-	-	-	-	-	-	-
Distance	-	-	-	-	-	-	-	-	-	-	-	-	0.019	0.005 – 0.033	< 0.01	-0.013	-0.025 - - 0.001	0.04
Sidewalks	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-0.074	-0.126 - - 0.021	< 0.01
Bike Lanes	0.049	0.021 - 0.078	< 0.01	-0.049	-0.083 - - 0.015	< 0.01	0.047	0.011 – 0.084	0.01	-0.057	-0.101 - - 0.013	0.01	-	-	-	-	-	-
Crime Safety	0.043	0.011 – 0.076	< 0.01	-	-	-	0.053	0.011 – 0.094	0.01	-	-	-	0.070	0.023 – 0.117	< 0.01	-	-	-
Pleasure	-	-	-	0.102	0.008 – 0.197	0.03	-	-	-	0.165	0.043 – 0.287	< 0.01	-	-	-	0.124	0.012 – 0.236	0.03
Aesthetics	-	-	-	-0.148	-0.264 - - 0.032	0.01	-	-	-	-0.223	-0.372 - - 0.074	< 0.01	-	-	-	-0.180	-0.316 - - 0.043	0.01
Study Environmen	-	-	-	-	-	-	-	-	-	-	-	-	0.048	0.002 – 0.093	0.04	-	-	-

BMI – Body Mass Index; WC – Waist Circumference; BF – Body Fat; 95% CI – 95% Confidence Interval.

*1 - Adjusted to age, gender, SES and BMI at baseline.

*2 - Adjusted to age, gender, SES and WC at baseline.

*3 - Adjusted to age, gender, SES and BF at baseline.

Discussion

At the best of our knowledge, this is the first longitudinal study addressing associations between perceived environmental features, PF and body composition among Portuguese adolescents. In boys, facilities within longer distance at baseline were associated with lower CRF, muscular strength (long jump test) and agility at follow-up. Boys' lower study environment perceptions at baseline were associated with higher percentage of BF at follow-up. Perceptions of distant facilities at baseline were positively associated with higher muscular strength (handgrip test) at follow-up in girls. Also, the presence of bike lanes and positive aesthetics perceptions at baseline were associated to a lower BMI at follow-up in girls.

Additionally, our findings showed that, in general, all PF and body composition variables improved and increased, respectively, over time. PF results aligned with the existing literature which has shown that the 20 meter shuttle run (Rodrigues et al., 2013; Telford et al., 2016), handgrip (Freitas et al., 2012; Souza et al., 2016), long jump (Freitas et al., 2012; Rodrigues et al., 2013; Souza et al., 2016) and agility 4x10m (Souza et al., 2016) tests improve throughout adolescence, although improvements are more noticeable in boys than girls.

We had also found that lower home environment perceptions were associated with higher CRF over time. This result contradicts previous findings showing that higher levels of activity are often associated with owning sport equipment (Lowry et al., 2013; Maddison et al., 2009). Nonetheless, these studies were cross-sectional, whereas the present study looked for associations over time. Previous cross-sectional data with Portuguese adolescents has shown that those living in rural environments had better CRF than the ones on urban environments (Machado-Rodrigues et al., 2011; Machado-Rodrigues et al., 2012). In fact, neighborhood characteristics such as houses, schools, sidewalks and parks are important features that can influence PA (Tester, 2009).

Notwithstanding, distance to local facilities also presents an opportunity for youth to be fitter. In this context, our research suggested that longer distance

to facilities at baseline was associated with lower CRF in boys at follow-up. Conversely, previous research showed that facilities within a shorter distance were associated to higher levels of activity (Boone-Heinonen et al., 2010; Cohen et al., 2006; Giles-Corti et al., 2009; Ries et al., 2008). Therefore, we could speculate that longer distance to facilities may act as a barrier for engaging in PA and impact CRF. Concurrently, one study (Vanhelst et al., 2013) reported that adolescents that could use a safe path from home to school by walking or cycling and had nearby facilities presented better fitness than their peers. Nevertheless, in that study, traffic density around the neighborhood was negatively associated with PF particularly, with speed/agility (4x10m test) and lower-body muscular strength (standing long jump test) (Vanhelst et al., 2013).

The present study also found that boys with a more pleasant neighborhood at baseline had higher agility' at follow-up and those who perceived distant facilities at baseline had lower muscular-strength (long jump test) and agility at follow-up. Despite using different questionnaires, similar results were found in a sample of 3528 European adolescents (Vanhelst et al., 2013). These authors reported that perceiving local facilities was associated with a better performance on the long jump test; and that perceptions of a poorer pleasant neighborhood and nearby facilities were associated with lower and higher agility, respectively (Vanhelst et al., 2013).

Moreover, we have also found that distant facilities were associated with lower BF percentage in girls. On the other hand, one study showed that the availability of recreational opportunities within 500m of the home environment was inversely associated with BMI in youth (Gilliland et al., 2012). Likewise, adolescents with access to at least one healthy outlet within 800m of their neighborhood had a 38% decreased risk of being overweight or obese comparing to their peers (Miller et al., 2014). Notwithstanding, it is important to notice that the previous studies (Gilliland et al., 2012; Miller et al., 2014) relied on self-reported measures of BMI whereas in our study BMI was objectively measured.

Regarding the associations between environmental perceptions and body composition variables, our results showed that perceiving a higher

residential density was associated with lower WC in boys and perceiving a positive sidewalks' availability was associated with a lower percentage of BF in girls. Meanwhile, one study showed that perceiving a lower residential density and sidewalks' availability was associated with a higher BMI (Duncan et al., 2014). Even though different methods were used to measure environmental features, both studies seem to suggest that a higher residential density and sidewalks availability are associated with a better body composition.

Literature regarding safety and body composition in youth is inconsistent. While some authors have reported inverse associations (Duncan et al., 2009; Oreskovic et al., 2009), others, did not find any relationship between body composition and neighborhood safety perceptions (Lange et al., 2011). Our study contributed to this body of knowledge by suggesting that higher crime safety perceptions were positively associated with BMI, WC and BF percentage in boys. Indeed in our study most of the participants did not consider safety a problem. Although only approximately 66% of the respondents thought their neighborhood was entirely safe, respondents who agreed with each individual question from this dimension ranged from 74.1% (bike stuck with a locket), 91.6% (crime during day) and 83.7% (crime during night) (data not shown).

Conclusions

Overall, PF variables improved over time in both genders. Body composition showed that all variables increased among all participants except boys' BF percentage.

Facilities within longer distance at baseline were associated with lower CRF, muscular strength (long jump test) and agility at follow-up in boys. Boys' lower study environment perceptions at baseline were associated with higher percentage of BF at follow-up. Perceptions of distant facilities at baseline were positively associated with higher muscular strength (handgrip test) at follow-up in girls. Also, the presence of bike lanes and positive aesthetics perceptions at baseline were associated to a lower BMI at follow-up in girls.

Study Limitations and Strengths

The strengths of this study include its longitudinal design, a large sample of adolescents, the use of a questionnaire specially developed for European contexts and the objective measurement of anthropometric measures. Nevertheless, limitations should be recognized. First, our sample is not representative of Portugal, since the geographical area was limited to the North of Portugal; and second, the weather and landscapes from this part of the country are substantially different from the centre and south parts of Portugal.

Conflicts of Interest

No conflicts of interest were reported by the authors of this paper.

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Chapter 4

Overall Discussion

The main findings of this thesis suggested that:

1. The ALPHA environmental questionnaire had moderate to good test-retest reliability in Portuguese Adolescents.
2. As expected, on average, body mass index increased, all physical activities intensities decreased and cardiorespiratory fitness improved over the 2-year period in both genders. Sedentary behavior increased only in boys.
3. In boys, higher residential density, longer distance to local facilities and better crime safety perceptions at baseline were associated with lower sedentary behavior at follow-up.
4. Lower home environment perceptions, in boys, and higher residential density perceptions, in girls, at baseline were negatively associated with light physical activity and moderate physical activity, respectively, at follow-up.
5. In boys, perceptions of a pleasant environment at baseline were associated to higher agility at follow-up; perceptions of higher distance to facilities at baseline were associated with lower cardiorespiratory fitness, muscular strength (standing long jump test) and agility at follow-up. In girls, perceptions of higher distance to facilities at baseline were associated with better muscular strength (handgrip) at follow-up.
6. Positive perceptions of bike lanes availability and aesthetics at baseline were associated with better body composition at follow-up, in girls. In boys, lower study environment perceptions at baseline were associated with worse body composition at follow-up.

ALPHA Questionnaire

The ALPHA environmental questionnaire had moderate to good test-retest reliability in Portuguese Adolescents. This is supported by previous

research on European adults (Spittaels et al., 2010) and Spanish youth (Garcia-Cervantes et al., 2014).

Adolescents' environmental perceptions can be assessed with several questionnaires (Dunton et al., 2003; Durant et al., 2009; Evenson et al., 2006; Rosenberg et al., 2009; Spittaels et al., 2010). However, only a few of those present a comprehensive set of activity-friendly environmental perceptions such as the ALPHA environmental questionnaire (Spittaels et al., 2010). Despite previous research in European adults (Spittaels et al., 2010) showed similar reliability results with our study (paper I), it is worthy of notice that in that study the authors reported more environmental dimensions with better scores than ours. Besides, intracorrelation coefficients were higher (0.66-0.86) than ours (0.55-0.80). Nevertheless, in the ALPHA reliability study with Spanish youth, the intracorrelation coefficients range was lower than ours (0.42-0.77) (Garcia-Cervantes et al., 2014). Although this presents similar reliability, direct comparisons cannot be performed since these authors applied an adapted version of this questionnaire.

Sedentary Behavior

Our findings showed that, on average, SB (for the exception of girls) and BMI increased over the 2-year period, which aligns with the literature for both SB (Atkin et al., 2013; Carson et al., 2013; Harding et al., 2015; Lawman et al., 2014) and BMI (Berry et al., 2010; Duncan et al., 2014; Freitas et al., 2012).

Environmental perceptions have been abundantly studied over the years in adolescents (Ding et al., 2011). Despite of these studies been mostly related with PA, studies on SB started to emerge in the past years (Maitland et al., 2013; Stierlin et al., 2015). Usually, studies show that girls have an increased likelihood of being sedentary in comparison with boys (Ekelund et al., 2012; Norman et al., 2010) and while the same can be seen at baseline of our study, the opposite can be found two years later, whereas SB increased in boys and decreased slightly in girls (paper II). Even though studies between SB and environmental perceptions are increasing, it is possible to verify that available data focus mostly on safety (Maitland et al., 2014; Veitch et al., 2013), green

spaces/parks (Dadvand et al., 2014; Storgaard et al., 2013), sport equipment availability (Lowry et al., 2013; Tandon et al., 2014) and differences between youth from rural and urban areas (Machado-Rodrigues et al., 2014; Salmon et al., 2013).

It is known that the neighborhood is an environmental feature that influences ones' behaviors. Commonly, adolescents prefer to travel to local facilities (Giles-Corti et al., 2009; Ries et al., 2008) maybe for being of easy access or safer. Regardless, our study (paper II) showed that boys' perceptions of facilities placed further away at baseline were associated with lower SB levels at follow-up. Although at first glance this seems inconsistent with the literature, one possible explanation would be the fact that maybe boys did not perceive distance as a barrier to engage in physical activities. Traffic safety is often considered a contributor for physical inactivity. Studies from Europe (Vanhelst et al., 2013) and New Zealand (Rehrer et al., 2011) revealed that adolescents that perceived more traffic were less active. Contrarily to what literature presents, our study indicated positive perceptions concerning traffic safety at baseline to be associated with higher SB at follow-up, in boys (after adjusting for BMI). We may hypothesize that while traffic is not considered a barrier to engage in PA, adolescents might prefer engaging in other activities outside their residential area. Additionally, existing data from US (Lowry et al., 2013) and New Zealand (Maddison et al., 2009) adolescents show that owning sport equipment is associated with lower SB levels. Despite the differences in the number of participants in each study, we found similar findings.

Physical Activity

PA is also a subject of study interest since it contributes with several health benefits (Janssen et al., 2010; WHO, 2010). Despite these benefits, few adolescents attain PA recommendations (Ruiz et al., 2011b). In fact, in our study (paper III), all PA intensities decreased over time as shown elsewhere for LPA (Harding et al., 2015; Marks et al., 2015; Morton et al., 2016), MPA (Collings et al., 2015; van Sluijs et al., 2016), MVPA (Collings et al., 2015; Harrison et al., 2015; Marks et al., 2015; Morton et al., 2016; Taverno Ross et

al., 2014) and VPA (Collings et al., 2015; Harrison et al., 2015; Janz et al., 2014).

Some years ago, a Portuguese study (Baptista et al., 2012) revealed that the rate of young people, aged 10 to 18 years old, that engaged for at least 60 minutes of MVPA was very low (approximately 30% in boys and 10% in girls). This supports the idea that girls have an increased likelihood of being classified as sedentary (Ekelund et al., 2012; Norman et al., 2010). In our study (paper III), at baseline, it was found that, on average, boys engaged in more than 60 minutes of MVPA while the same was not found for girls.

As it was previously mentioned, environmental features have a key role on modulating movement behaviors. Features such as recreational facilities, sidewalks and bike lanes, safety, aesthetics, parks and the weather have been consistently associated with adolescents' PA levels (Ding et al., 2011; McGrath et al., 2015). Notwithstanding, most studies have only considered total PA or MVPA. However, a couple of studies from the US have shown that LPA was associated with the proximity of parks (Rodriguez et al., 2012) and the presence of sidewalks (Jago et al., 2006; Jago et al., 2005) in youth. On the other hand, we showed (paper III) that higher residential density and lower home environment perceptions at baseline were negatively associated with LPA over a 2-year period. The same was found in regards to residential density perceptions at baseline and MPA at follow-up. Furthermore, our study also showed that positive traffic safety perceptions at baseline were associated with low MPA levels at follow-up. Usually, in youth, low traffic perceptions are associated to lower PA levels (Carver et al., 2009; Hume et al., 2009) and negative associations can also be found between traffic and MVPA (Oliver et al., 2015; Rodriguez et al., 2012). Similarly, an US longitudinal study showed that crime rate was associated with MVPA decrease (Boone-Heinonen et al., 2010a). On the other side, positive perceptions concerning the presence of schools and parks were associated to the increased probability of engaging in MVPA (Rodriguez et al., 2012). Concurrently, an US study showed that there is an increased likelihood for youth to engage in MVPA in parks and playgrounds than staying at home (Oreskovic et al., 2015). Despite this, we did not find

associations regarding MVPA and VPA. Still, studies from UK (Coombes et al., 2013) and US (Han et al., 2013) reveal that VPA is positively associated with PA facilities.

Physical Fitness and Body Composition

Our study (paper IV) showed that PF results were in line with previous data regarding 20 meter shuttle run test (Rodrigues et al., 2013; Telford et al., 2016), handgrip (Freitas et al., 2012; Souza et al., 2016), long jump (Freitas et al., 2012; Rodrigues et al., 2013; Souza et al., 2016) and agility 4x10m (Souza et al., 2016) tests which improved over time, although improvements were more noticeable in boys than girls.

Identically to SB and PA, PF may also be influenced by environmental features in adolescents. Even though data on environmental features and PF is scarce, one European study showed that nearby facilities were associated with higher PF levels (Vanhelst et al., 2013). Conversely, our study (paper IV) showed that higher distance to facilities at baseline was associated with lower CRF, muscular strength (standing long jump test) and agility at follow-up in boys.

Moreover, boys' positive perceptions regarding the pleasure of their neighborhood at baseline were associated to a higher agility at follow-up. Similar results were found in the literature (Vanhelst et al., 2013). Our findings (paper IV) also revealed that perceptions regarding neighborhood pleasure and aesthetics at baseline were positively and negatively associated, respectively, with BMI, WC and BF in girls at follow-up. Although neighborhood pleasure results may be contradictory, they might be explained. While girls might have found that their neighborhood was pleasant to walk or cycle, they might not consider it a reason to engage in physical activities. In order to be physically active and thus reduce body composition, girls may prefer the aesthetics rather than the pleasantness of the neighborhood, as seen in our study.

Besides these associations, it was also possible to find that boys' and girls' positive perceptions with regards to bike lanes availability at baseline were associated with higher BMI and WC over the 2-year period. One may speculate

that the reason for the differentiation of results among genders may rely on the fact that boys, generally, engage in other types of sedentary activities outside their residential area which aligns with our previous studies (paper II and III) while girls possibly stay longer at home. Still, girls' positive perceptions concerning sidewalks availability at baseline were associated with lower BF at follow-up. Similar findings were found in another US study with a large number of youngsters (Duncan et al., 2014) where poorer perceptions of sidewalks availability and lower residential density were associated with a higher BMI. Conversely, we have found that higher residential density perceptions at baseline were associated to a lower WC in boys. In spite of different applied methodologies, it is possible to find a connection between residential density and sidewalks availability with body composition. Other studies from UK (Gilliland et al., 2012) and Australia (Miller et al., 2014) indicated that local facilities up to 500m and healthy-food outlets within 800m, respectively, were associated with lower BMI in youth. On the other hand, our study showed that facilities located further away at baseline were associated with higher BF in boys at follow-up, whilst the opposite was found in girls. Moreover, in spite of other US cross-sectional studies with large samples indicate an inverse association between safety and body composition in adolescents (Duncan et al., 2009; Oreskovic et al., 2009) our study did not support these findings. Boys with better perceptions of crime safety at baseline had higher BMI, WC and BF at follow-up. Throughout this study (paper IV), it was possible to verify that, generally, boys had positive perceptions about the settings of their neighborhood though their body composition increased, which showed that they might prefer to engage in sedentary rather than physical activities.

Since the study of environmental perceptions is growing, it is crucial to understand how these associate, longitudinally, with SB, PA intensities, PF and body composition in adolescents. Still, while adolescence is one of the main sedentary population groups, realizing which environmental features affects adolescents the most will help preventing risk behaviors in adulthood.

Chapter 5

Conclusions

Based on the findings of the present thesis, we highlight the following conclusions:

1. The ALPHA environmental questionnaire had moderate to good test-retest reliability in Portuguese Adolescents.
2. As expected, on average, body mass index increased, all physical activities intensities decreased and cardiorespiratory fitness improved over the 2-year period in both genders. Sedentary behavior increased only in boys.
3. In boys, higher residential density, longer distance to local facilities and better crime safety perceptions at baseline were associated with lower sedentary behavior at follow-up.
4. Lower home environment perceptions, in boys, and higher residential density perceptions, in girls, at baseline were negatively associated with light physical activity and moderate physical activity, respectively, at follow-up.
5. In boys, perceptions of a pleasant environment at baseline were associated to higher agility at follow-up; perceptions of higher distance to facilities at baseline were associated with lower cardiorespiratory fitness, muscular strength (standing long jump test) and agility at follow-up. In girls, perceptions of higher distance to facilities at baseline were associated with better muscular strength (handgrip) at follow-up.
6. Positive perceptions of bike lanes availability and aesthetics at baseline were associated with better body composition at follow-up, in girls. In boys, lower study environment perceptions at baseline were associated with worse body composition at follow-up.

Perspectives for further research

The findings of this thesis show several longitudinal associations between environmental perceptions and SB, PA intensities, PF and body composition variables. Since longitudinal studies on this area are scarce, further research is necessary to help understand the key environmental factors that affect youth during adolescence in order to be able to implement strategies and/or interventions that aim to aid adolescents becoming healthier adults.

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