Universidade do Porto.
Centro de Investigação em Actividade Física, Saúde e Lazer da Faculdade de Desporto.

Behavioural and Biological Risk Factors for Cardiovascular Diseases in the Azorean Population.

Obesity, Physical Activity and Perceived Environmental Attributes in the Azorean Population.

Este trabalho foi desenvolvido no Centro de Investigação em Actividade Física, Saúde e Lazer (CIAFEL), da Faculdade de Desporto da Universidade do Porto, unidade de Investigação da Fundação para a Ciência e Tecnologia. A presente dissertação foi escrita para a obtenção do título de Doutor no âmbito do Curso de Doutoramento em Actividade Física e Saúde, organizado pelo CIAFEL. Este trabalho foi apoiado pela Fundação da Ciência e Tecnologia através da bolsa BD/22587/2005 e pelo Governo da Região Autónoma dos Açores.

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Palavras-chave: OBESITY; PHYSICAL ACTIVITY; WALKING; ENVIROMENT; AZORES.

Walking is one of the first things an infant wants to do, and one of the last any of us wants to give up…

in Sussman A, Goode R. *The Magic of Walking*, Simon and Schuster, 1967.

Ao Luís, por ter feito esta viagem de mão

dada comigo.

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Resumo

A obesidade e a falta de actividade física (AF) são importantes factores de risco de uma série de doenças crónicas e estão associadas a vários factores do estilo de vida e do envolvimento.

Os objectives deste estudo em adultos Açorianos foram: artigo I) determinar e comparar a prevalência da obesidade e explorar os factores comportamentais associados; artigo II) descrever os padrões da AF e compará-los com outros países e descrever as associações entre a AF e outros factores do estilo de vida; artigo III) investigar associações transversais entre a marcha e o índice de massa corporal (IMC); artigo IV) determinar se as percepções das características do envolvimento se associam à AF, por género e IMC; artigo V) descrever os padrões de marcha e examinar as associações com factores sócio demográficos e as percepções das características do envolvimento.

Este estudo transversal contou com 9 991 adultos (artigos I, II a III) ou com 7330 adultos (artigos IV e V) que participaram no Estudo da Actividade Física e da Saúde dos Açorianos - Portugal em 2004. Todas as variáveis foram auto-reportadas. Aplicou-se a versão curta do *International Physical Activity Questionnaire* (IPAQ) para obtenção dos dados relativos à marcha, à AF e ao tempo sentado. O módulo do ambiente do IPAQ permitiu recolher informações sobre as percepções das características do envolvimento.

Os resultados mostraram uma prevalência de excesso de peso e de obesidade de 33.5 e 18.8% nas mulheres e de 45.8 e 16% nos homens, respectivamente. Em ambos os géneros, a idade foi um preditor positivo e o consumo de tabaco um preditor negativo do excesso de peso e da obesidade. Os homens com baixos níveis de AF e com um tempo sentado elevado ($\geq$ 3h/dia) apresentaram uma maior probabilidade de obesidade. Um baixo estatuto socioeconómico e o consumo de álcool foram preditores positivos do excesso de peso e da obesidade, nas mulheres. 23.6% das mulheres e 43.8% dos homens atingiram os níveis de AF recomendados para a manutenção de uma boa saúde. 57.1% dos participantes deste estudo atingiram as recomendações internacionais da AF. As mulheres atingiram com menor frequências as recomendações internacionais da AF, bem como os níveis de AF adequados para a manutenção de uma boa saúde. Em ambos os géneros, um nível de educação mais elevado, estar empregado, ter um rendimento mensal superior e estar sentado por mais de 3h/dia foram preditores negativos dos níveis de AF adequados à manutenção de uma boa saúde. Fazer pelo menos 5 refeições por dia foi um preditor positivo do nível de AF adequado à manutenção de uma boa saúde. A marcha não se relacionou significativamente com o IMC, após ajuste de confundidores. Nas mulheres, a dimensão do envolvimento Infra-estruturas, Acesso a Destinos, Envolvimento Social e Estética associou-se positivamente com os níveis moderados de AF de níveis de AF adequados à manutenção de uma boa saúde. Quando os participantes foram categorizados de acordo com o seu IMC a mesma dimensão associou-se a níveis moderados de AF apenas nas mulheres com excesso de peso ou obesidade. A dimensão do envolvimento Infra-estruturas, Acesso a Destinos, Envolvimento Social e Estética e a AF moderada e vigorosa associaram-se positivamente com os níveis de marcha. O consumo de tabaco, o tempo sentado e o ser casado foram preditores negatives da marcha, independentemente da idade, do género ou nível educacional dos participantes. A segurança não se associou aos níveis de AF nem aos de marcha.

Os programas de diminuição da prevalência da obesidade e de incremento da AF dirigidos aos Açorianos devem consideram uma abordagem multi factorial, uma vez que vários factores do estilo de vida e do envolvimento parecem interferir nos níveis de excesso de peso/obesidade e de AF desta população. Sugere-se uma monitorização regular desta população a fim de se analisarem tendências e se identificarem os subgrupos da população que são mais afectados pela falta de AF, pela obesidade e por outros factores de risco da saúde. A monitorização regular desta população pode igualmente servir de norteadora para a elaboração e acompanhamento de programas promotores de AF.

Palavras-chave: OBESIDADE; ACTIVIDADE FÍSICA; MARCHA; ENVOLVIMENTO; AÇORES.

Abstract

Obesity and the lack of physical activity (PA) are important risk factors for many chronic diseases and are associated with several lifestyles and environmental factors.

The aims of this study in Azorean adults were: paper I) to determine and compare the obesity status and to explore social and behavioural factors associated with obesity i; paper II) to describe PA prevalence and compare it with other countries and to investigate possible associations between physical activity and other lifestyle behaviors; paper III) to investigate the cross-sectional associations between walking and body mass index (BMI); paper IV) to determine whether perceived neighbourhood attributes were associated with reported PA levels, by gender and BMI categories; paper V) to describe walking patterns and to examine associations between socio-demographic characteristics and perceived environmental attributes with walking.

In this cross-sectional study, the sample comprised 9 991 adults (papers I, II and III) or 7330 adults (papers IV and V) who participated in the Azorean Physical Activity and Health Study – Portugal, in 2004. All variables were self-reported. Walking, PA and sitting time were assessed by the International Physical Activity Questionnaire – short version (IPAQ). The environmental module of the IPAQ assessed perceived environmental characteristics.

Results showed that the prevalence of overweight and obesity was 33.5 and 18.8% in women, and 45.8 and 16% in men, respectively. Age was a predictor of overweight and obesity, in both genders. Smoking status was negatively associated with overweight and obesity, in both genders. Men with low physical activity level and higher sitting time (≥ 3h/day) were more likely to be obese. Low socio-economic status and alcohol consumption were found to be predictors for overweight and obesity for women. The prevalence of Health-enhancing physical activity (HEPA) individuals was 23.6% for women and 43.8% for men. 57.1% of the participants met current PA recommendations. Women were less likely to achieve PA recommendations, as well as the HEPA level. In both genders, higher education level, employment status, higher income and sitting for more than 3h/day were negative predictors of HEPA; and, having at least 5 meals/day was positive predictor for the same PA level. Walking was not a significant predictor of BMI after adjustments for potential cofounders, in either gender. After adjustments, the dimension Infrastructures, Access to Destinations, Social Environment and Aesthetics was positively associated with moderate PA level and HEPA level, only in women. When participants were categorized by BMI status, the same dimension was a significant predictor for moderate PA level in normal weight men and women, and for HEPA level only in overweight/obese women. The environmental dimension Infrastructures, Access to Destinations, Social Environment and Aesthetics and moderate to vigorous physical activity were positively associated with walking levels; and smoking, sitting time and being married were negatively related, regardless of gender, age or education level. Safety was not associated with PA or walking levels.

Targeted programmes aimed to low the prevalence of overweight and obesity, and to increase PA levels among the Azoreans, should consider a multi factorial approach once several lifestyle and environmental factors seem to affect overweight/obesity and PA levels, in this population. Among Azoreans, regular surveillance is required in order to monitor, study trends over time and analyze the population subgroups that are most affected by the lack of PA, obesity and other health related outcomes. Future studies may also offer guidance for PA promotion programs.

Key-words: OBESITY; PHYSICAL ACTIVITY; WALKING; ENVIROMENT; AZORES.

Resumé

L'obésité et le manque d'activité physique (AF) constituent d'importants facteurs de risque d'un ensemble de maladies chroniques et se trouvent associées à divers facteurs du style de vie et de l'environnement.

Les objectifs de la présente étude sur des individus adultes des Açores sont les suivants : article I) déterminer et comparer la prévalence de l'obésité et explorer les facteurs comportementaux associés; article II) décrire les récurrences (modèles) de l'AF et les comparer à ceux d'autres pays, et décrire les associations entre l'AF et d'autres facteurs du style de vie ; article III) chercher des associations transversales entre la marche et l'indice de masse corporelle (IMC) ; article IV) déterminer si les perceptions des caractéristiques de l'environnement s'associent à l'AF, selon le sexe et l'IMC ; article V) décrire les modèles de marche et examiner les associations avec des facteurs sociodémographiques et les perceptions des caractéristiques de l'environnement.

Cette étude transversale s'est appuyée sur l'observation de 9991 individus adultes (articles I, II à III) ou 7330 adultes (articles IV et V) qui ont participé à l'Etude de l'Activité Physique et de la Santé des Açoriens — Portugal en 2004. Toutes les variables ont été auto-rapportées. La version abrégée de *l'International Physical Activity Questionnaire* (IPAQ) a été appliquée pour l'obtention des données relatives à la marche, à l'AF et au temps de permanence en position assise. Le module du l'environnement de l'IPAQ a permis de recueillir des informations sur les perceptions des caractéristiques de l'environnement.

Les résultats ont démontré une prévalence d'excès de poids et d'obésité de 33,5% et 18,8% chez les femmes et de 45,8% et 16% chez les hommes, respectivement. Dans les deux sexes, l'âge a été un prédicteur positif et la consommation de tabac un prédicteur négatif de l'excès de poids et de l'obésité. Les hommes avec de bas niveaux de AF et une permanence élevée en position assise (≥ 3h/jour) ont présenté une plus grande possibilité d'obésité. Un faible statut socioéconomique et la consommation d'alcool ont été des prédicteurs positifs de l'excès de poids et de l'obésité chez les femmes. 23,6% des femmes et 43,8% des hommes ont atteint les niveaux d'AF recommandés pour la manutention d'une bonne santé. 57,1% des participants de cette étude ont atteint les recommandations internationales de lAF. Les femmes ont atteint avec une moindre fréquence ces recommandations, ainsi que les niveaux d'AF recommandés pour la manutention d'une bonne santé. Dans les deux sexes, un niveau d'éducation plus élevé, être employé, avoir un revenu mensuel supérieur et rester assis plus de 3h/jour ont été des prédicteurs négatifs des niveaux d'AF adéquats à la manutention d'une bonne santé. Faire au moins cinq repas par jour a été un prédicteur positif du niveau d'AF adéquat à la manutention d'une bonne santé. Il n'a pas été établi une relation directe et signifiante de la marche avec l'IMC, après le réajustement d'autres variables. Chez les femmes, la dimension de l'environnement Infrastructures, Accès aux Destinations, Environnement Social et Esthétique s'est associée positivement aux niveaux modérés de AF adéquats à la manutention d'une bonne santé. Quand les participants ont été répertoriés en accord avec leur IMC, la même dimension a été associée à des niveaux modérés d'AF seulement chez les femmes en situation d'excès de poids ou d'obésité. La dimension de l'environnement Infrastructures, Accès aux Destinations, Environnement Social et Esthétique et l'AF modérée et vigoureuse ont été associés positivement aux niveaux de marche. La consommation de tabac, la permanence assise et le fait d'être marié ont été des prédicteurs négatifs de la marche, indépendamment de l'âge, du sexe ou du niveau d'éducation des participants. La sécurité n'a pas été associée aux niveaux d'AF ni à ceux de la marche.

Les programmes de diminution de la prévalence de l'obésité et de l'augmentation de l'AF dirigée aux Açoriens doivent considérer un abordage multifactoriel, étant donné que divers facteurs du style de vie et de l'environnement semblent faire interférence sur les niveaux d'excès de poids/obésité et de l'AF de cette population. Il est suggéré faire un accompagnement régulière de cette population afin d'analyser les tendances et d'identifier les sous-groupes de la population les plus affectés par le manque de AF, par l'obésité et par d'autres facteurs de risques pour la santé. L'accompagnement régulier de cette population peut également servir d'orientation pour l'élaboration et l'accompagnement de programmes promoteurs d'AF.

Mots-clé : OBESITÉ ; ACTIVITÉ PHYSIQUE ; MARCHE ; ENVIRONNEMENT ; AZORES

Índice de Quadros

Lista de Abreviaturas:

APAHS – Azorean Physical Activity and Health Study
BMI – Body Mass Index
CI – Confidence intervals
CVD – Cardiovascular Disease(s)
HDL-C – High Lipoprotein Cholesterol
LDL-C – Low Lipoprotein Cholesterol
MVPA – Moderate and Vigorous Physical Activity
OR – Odds ratio
PA – Physical Activity(ies)
SES – Socio-economic status
WHO – World Health Organization

1. Introduction and Background

1. Introduction and Background

In the last two decades lifestyle changes due to industrialization, urbanization, economic development and marketing globalization have been remarkable, rapid and with important health consequences to the populations. Despite improved living standards, expended food availability and increasing access to services, there has also been significant negative consequences in terms of inappropriate dietary patterns, decreasing physical activity (PA) and increasing tobacco use, with a correspondent increase in lifestyle related chronic diseases, particularly in western countries [1]. Chronic diseases are mostly preventable diseases. Beyond the appropriate medical treatment for those already affected, primary prevention is the public health approach considered to be the most cost-effective, affordable and sustainable strategy to manage the chronic disease epidemic worldwide [1]. Although age, gender and genetic susceptibility are non-modifiable risk factors for many chronic diseases, several of the risks associated with age and gender are modifiable. Such risks include: behavioural factors (i.e. diet, physical inactivity, tobacco use, alcohol consumption); biological factors (i.e. dyslipidemia, hypertension, overweight, hyperinsulinaemia); and societal factors including a complex mixture of interacting socioeconomic, cultural and other environmental parameters [1].

Worldwide cardiovascular diseases (CVD) are the leading cause of death. Such diseases caused almost 32% of all deaths in women and 27% in men in 2004 [2]. In Portugal, the latest estimates indicate that, in each year, 39% of deaths in adults are due to CVD [3]. This prevalence is among the highest in Europe [4] and it has increased significantly, from 26.4 in 1960 to 38.7% in 2000 [3].

In 2002, The World Health Report highlighted the major death risk factors in the developed countries of North America, Europe and Asian Pacific: tobacco; alcohol; high blood pressure; high serum cholesterol levels; high body mass index (BMI); low fruit and vegetables intake and physical inactivity. Furthermore, in these countries more than three-quarters of CVD result from tobacco use, high blood pressure or cholesterol, or their combination [5].

Smoking and alcohol consumptions are important risk factors for CVD [6]. Smoking has decline in the past 20 years in the majority of the countries of the European Union, but not in Portugal [7]. However, in Portugal like in most European Union countries, total alcohol consumption levels have been falling [7, 8]. Portuguese data indicate that the prevalence of alcohol consumers and the total amount of alcohol consumed have decreased slightly but significantly between 1995/96 and 1998/1999 [8].

Another important risk factor for CDV is obesity [9].

Obesity has become an important epidemic both in developed and developing countries due to its association with increased morbidity and mortality [10]. Worldwide, the World Health Organization (WHO) estimates that one billion people are overweight and it is estimated that this number may reach 1.5 billion by 2015 if the current trend continues [11]. In Europe, the prevalence of overweight and obesity combined (BMI≥25 kg/m^2) in men ranges from 32.9% (in Sweden) to 65.8% (in the UK), and in women from 29.5% (in Italy) to 54.3% (in the UK) [12]. In the European Union alone, it is estimated that over 200 million adults may be overweight or obese – that is over half the adult population [13].

Overweight and obesity have also reached epidemic proportions in Portugal [14-16]. The Portuguese prevalence of overweight (34.4% in women and 45.5% in men) and obesity (13.4% in women and 15% in men) is high, but it has increased only slightly in the past decade [14, 16] in contrast with other countries [17-20].

Several studies in the USA and in Europe have shown that the prevalence of persons with a BMI>25 Kg/m^2 is higher among men compared with women [17, 21, 22].

Regarding age, it is known that older men and women are more frequently overweight or obese compared with their younger counterparts [17, 18, 23, 24]. Typically, in the developed countries, adults tend to gain weight between the third and the sixth decade, after this period weight is often maintained, followed by a modest decrease in the ninth decade [25].

There is also evidence that obesity is socio-economically distributed. In developed countries, persons of lower socio-economic position are more likely

to be affected, while in developing countries, those of higher socio-economic position are often the overweight or obese ones. In fact, in developed societies, the socio-economic distribution of eating patterns and leisure time PA are coincident with the one found for obesity [26]. Literature in Portugal [14], and in other developed countries [20, 22, 24, 27-31] has found an inverse association between socio-economic position and BMI, especially in women. Some investigators have suggested that individuals of lower socio-economic backgrounds report less leisure time PA and/or are less likely to consume healthy or low-fat diets [32-39] than those of higher socio-economic backgrounds. Education is positively associated with more health-related knowledge [40] and a higher capacity to put it into practice [26]. On the other hand, individuals with low incomes have less access to healthy food (usually more expensive) and are less able to pay for exercise classes or to buy sport equipment [26]. In addition, women are also more likely to perceive themselves as overweight, more concerned about their body weight and image and are more aware of their weight status [40]. Dieting and weight control efforts are more common among women in the high strata [34].

Literature has described an inverse association between smoking habits and overweight/obesity [23, 40, 41]. However, the health benefits of smoking cessation exceed the risk associated to any small rise in BMI that may follow giving up smoking [41], since smoking is associated with a variety of diseases, including CVD and cancer [42]. In addition, overweight non-smokers have a longer life expectancy than thin smokers [43, 44] and smokers tend to cluster other risk behaviours like low leisure time PA, high alcohol consumption and low fruit/vegetable intake [45].

Data from USA indicate some ethnic disparities in the obesity prevalence. It is known that the prevalence of obesity, in adults, is higher among non-Hispanic Blacks, Mexican Americans [17], American Indians, Alaska Natives, Hispanic/Latinos, Native Hawaiians and Pacific Islanders compared with non-Hispanic Whites [46]. The social inequities, minorities are traditionally exposed to, may contribute to these ethnic disparities in the prevalence of obesity. It is possible that in some ethnicities overfeeding is used as a

mechanism to cope with stress or that children are overfed as "insurance" against hunger [47]. Some investigations have pointed out ethnic differences in calories, fat and fast food consumption [48, 49] as well as in levels of sedentary behaviours [48, 50]. It also known that African American women are more likely to accept a larger ideal body image [51-53] and that those who are overweight are less likely to perceive themselves as so [54].

The health consequences of obesity include physical, psychological and social aspects, having a strong effect on quality of life.

Among the adverse medical consequences of overweight in adults, type 2 Diabetes is the most strongly linked with increasing BMI [55]. In fact, the worldwide obesity epidemic portends the diabetes epidemic as well as its serious health consequences, including CVD [46]. Several cross-sectional [56, 57] and prospective studies [58-61] have demonstrated a positive relation between obesity and type 2 Diabetes. The consistency of this association in several populations, in studies with different type 2 Diabetes classification criteria and in studies with different measures of fatness supports the strength of the association between obesity and Type 2 Diabetes [10]. For instance, the Nurses' health study showed that women with a BMI$\geq$31 Kg/m^2 had a relative risk of 40 for type 2 Diabetes, compared with the women with a BMI<22 Kg/m^2, after a 14 years follow up [60]. The risk of type 2 diabetes mellitus increases with the degree and duration of overweight and with a more central distribution of body fat [62].

Another important health problem related to obesity is the Metabolic Syndrome. Several cross-sectional studies have demonstrated that a higher BMI is associated with the metabolic syndrome components [63-65]. Weight gain after young adulthood is also associated with an increased prevalence of CVD risk factors later in life. For example, a 15 years longitudinal cohort study in young American adults (the CARDIA Study) showed that participants that maintained stable BMI into middle age may prevent the progression of other CVD risk factors and the development of metabolic syndrome, even if they were already overweight at baseline. Nevertheless, weight control before young adulthood should still be emphasized because baseline BMI was not

unimportant and because those with higher BMI at baseline appear to be more likely to continue to increase their BMI [66].

Weight lost may reverse or at least restrain the adverse effects of obesity. Some lifestyle intervention studies have shown that weight loss is effective in improving CVD risk factors, like blood pressure [67, 68], metabolic syndrome and lipid disorders [69], insulin resistance and type 2 Diabetes [70].

The adverse health outcomes related to obesity are not limited to CVD, and CVD risk factors. In adults, obesity increases the risk of erectile dysfunction [71], male infertility [72], Alzheimer disease [73], depression [74], dementia [75], osteoarthritis [76, 77], gastroesophageal reflux disease [78] obstructive sleep apnea [79], asthma [79], and several types of cancer [80-83]. Obesity is also related to physical disability [84], musculoskeletal disorders [85], employee absenteeism [86], impaired quality of life [87, 88] and increased health care costs [89, 90]. Data from 2001 in Canada, for example, indicate that the cost associated with obesity was $4.3 billion ($1.6 billion of direct costs and $2.7 billion of indirect costs) and the total economic costs of obesity represented 2.2%, of the total health care costs [91].

A number of studies showed an association between a BMI≥30kg/m^2 and mortality [92] or other measure of adiposity and mortality [93]. Indeed, data from the Framingham Study demonstrated that non-smoking women and men with a BMI≥25 Kg/m2 at the age of 40 lost 3.3 years and 3.1 years of life expectancy, respectively, compared with normal weight women and men [44].

Although genetics is a strong component of obesity [94], lifestyle and environmental changes typical of industrialized societies, are more likely to explain the recent obesity epidemic. Indeed, for a better understanding of the aetiology of obesity, the traditional energy-balance equation (caloric intake vs energy expenditure) has been expanded into a broader 'ecological model' [95, 96]. The elements of this model are the classic epidemiological triad: host, vector, and environment. The host includes all the individual related factors such as biological and metabolic factors, behaviours, knowledge and attitudes. The vectors are the energy-dense foods and drinks, large portions sizes, machines that reduce physical work or promote passive recreation. Finally, the

environment incorporates policy and the physical, economic and socio-cultural environments. This Epidemiological Triad has proven to be a robust model for other epidemics and is applied to obesity. Therefore a well-resourced, comprehensive, population-based set of strategies is needed to attenuate and eventually reverse the current trends of increasing obesity prevalence now apparent in most countries [95, 96].

Obesity prevention in adults is likely to have a major impact in reducing morbidity and mortality that result from the chronic effects of excessive body fatness [10]. Obesity prevention in the population at large should be emphasized to prevent the development of obesity not only in those adults who are still in the normal weight range but also in the successive generations of children and adolescents. Although treatment will continue to be of vital importance, it will not be enough to reduce the obesity epidemic. Besides the limited long-term success of most obesity treatments, another factor is the limited ability to deliver enough treatment to enough people [46].

Closely connected with obesity is another important CVD risk factor, the lack of PA.

In adults, the lack of PA is recognized as a major health concern in most industrialized countries, due to its contribution to a multiplicity of negative health outcomes [93, 97-101]. Three of the first six major death risk factors highlighted by the WHO (2002) are closely related to physical inactivity (high blood pressure, high serum cholesterol levels and high BMI) and physical inactivity itself is ranked in 7th in the list. Globally, it was estimated that, in the year 2000, 1.9 million deaths were due to physical inactivity [5]. In the WHO European Region physical inactivity is estimated to account for nearly 600 000 deaths per year (5 to 10% of deaths depending on the country) and leading to a loss of 5.3 million years of healthy life due to premature mortality and disability per year [102]. In addition, physical inactivity is also related to an increasing use of hospital services [103, 104] and globally, it accounts for a considerable economic burden representing 1.5 to 3% of total healthcare costs [105]. Canadian data from 2001 reveal that the economic burden of physical inactivity represented costs of $5.3

billion ($1.6 billion in direct costs and $3.7 billion in indirect costs) accounting for 2.6% of the total health care costs [91].

The modern scientific study of PA has its beginnings, in a context of post war aspirations of building a better world [106], soon after the Second World War and focused on the epidemic of CVD which started engulfing the Western world [97].

In 1953, Morris et al [107], in a seminal paper, reported that the conductors working in London's double-deck buses who climbed around 600 stairs per day experienced less than half the incidence of total coronary heart disease than the sedentary drivers who sat for 90% of their working hours (1.9 per 1 000 year $^{-1}$ in conductors compared with 2.7 per 1 000 year $^{-1}$ in drivers) and that the number of sudden deaths among drivers were more than twice as high compared with the conductors. However, Morris recognized that drivers and conductors might 'self-select' themselves into their different jobs and that the 'mental strains' of driving and conducting were very different. Nevertheless, he broadly concluded: that the greater PA of "conducting" (in these double-decker vehicles) is a cause of the lower incidence and mortality amongst conductors' [97]. In the following years research has studied the relation between PA and CVD. The work of Taylor with the Railway Men Study [108] and the Paffenbarger' San Francisco Longshoremen Study [109] represented important contributions. Even though these initial studies had important limitations: the samples only comprised men; other features that predict mortality like, obesity or smoking status were not considered and leisure time PA was also not taken into account., they inspired the subsequent investigations with better experimental designs.

During the 70's and 80's research in this area focused on leisure time PA.

In 1973, Morris et al. [110] presented the Whitehall Study on recreational or leisure-time PA. In this study the authors found that in men recording some vigorous exercise the relative risk of developing coronary disease was about a third when compared with men who did not, and in men reporting much of

vigorous PA still less. Lighter exercise, and provisional estimates of overall activity, showed no such advantage.

One of the most prominent studies of the 80's was the Harvard Alumni Health study. In this study of 16 936 men, followed for 12 years, Paffenbarger et al [111] found a steadily decline in death rates as energy expended on PA increased from less than 500 to 3 500 kcal per week, beyond which rates increased slightly. Rates were one quarter to one third lower among alumni expending 2 000 or more kcal during exercise per week than among less active men. Considering or not hypertension, cigarette smoking, extremes or gains in body weight, or early parental death, alumni mortality rates were significantly lower among the physically active ones. By the age of 80, the amount of additional life attributable to adequate exercise, when compared with sedentariness, was one to more than two years.

In 1989, the Aerobics Centre Longitudinal Study of Blair and colleagues [112] advanced considerably the argument that moderate-intensity activity was a more effective public health tool to reduce all-cause mortality at a time when heart disease was the greatest killer [97]. This investigation was the first to include women and in instead of relying on PA questionnaires, physical fitness was measured using a treadmill. After 8 years follow up, age-adjusted all-cause mortality rates declined across physical fitness quintiles from 64.0 per 10 000 person-years in the least-fit men to 18.6 per 10 000 person-years in the most-fit men (slope -4.5). Corresponding values for women were 39.5 per 10 000 person-years to 8.5 per 10 000 person-years (slope -5.5). These trends remained after statistical adjustment for age, smoking habit, cholesterol level, systolic blood pressure, fasting blood glucose level, parental history of coronary heart disease, and follow-up interval. Lower mortality rates in higher fitness categories were also seen for CVD and cancer of combined sites [112].

In 1992, Blair et al [113] re-examined the major epidemiological studies, concluding that the data supported public health recommendations directed toward the most sedentary and unfit stratum of the population with an emphasis on moderate-intensity PA, and that the key factor was total, accumulated

energy expenditure. In this same year the American Heart Association recognizes inactivity as a risk factor for coronary artery disease [114].

Since then, literature has confirmed the association between PA and incidence of fatal CVD. In 1990, a meta-analysis of Berlin and Colditz [115] showed a relative risk of death from coronary heart disease of 1.9 (95%CI:1.6-2.2) for sedentary occupations compared with active ones. Data from a Danish cohort of 13 375 women and 17 265 men, showed among the moderately and highly active persons, sports participants experienced only half the mortality of nonparticipants (after adjustments for age, systolic blood pressure, total cholesterol, triglycerides, smoking status and years of education) and bicycling to work decreased the risk of all-cause mortality in approximately 40% after multivariate adjustments, including leisure time PA. In this study a dose-response relationship was found in both women and men, with the most striking difference in mortality between the inactive group compared with others [116]. Similarly, data from the Puerto Rico Heart Health Program demonstrated a dose-response reduction in all-cause mortality risk with increasing levels of PA, in men. After adjustments (age, education, smoking status, hypertension status, hypercholesterolemic status, urban/rural residence, and overweight status) the authors found that PA was independently related to all-cause mortality. All-cause mortality was lower in those in PA quartile 2 (OR=0.68, 95%CI:0.58-0.79) than in PA quartile 1 (reference, sedentary group). Mortality among those in PA quartile 3 and 4 (OR=0.63, 95%CI:0.54-0.75; and OR=0.55, 95%CI:0.46-0.65, respectively) were also significantly lower than on those observed in the PA quartile 1, but not significantly lower than among those observed in quartile 2. Furthermore, within every category of body weight, those who were most active had significantly lower odds ratio of all-cause mortality [117]. The work of Wannamethee et al (2000) with a cohort of older British men also illustrated a dose response reduction in all-cause mortality risk across PA categories, observed in every age groups, among those with cardiac symptoms. The relationships were similar for all-cause mortality and for cardiovascular deaths [118]. More recently, Leitzmann et al (2007) showed in a cohort of 252 925 men and women aged 50 to 71 that compared with being inactive, achievement of

PA levels that approximate the recommended moderate PA (at least 30 minutes on most days of the week) or vigorous exercise (at least 20 minutes 3 times per week) was associated with a 27% and 32% decreased mortality risk, respectively. PA reflective of meeting both recommendations was related to substantial decrease in mortality risk overall (50%) and in subgroups, including smokers (52%) and non-smokers (46%), normal weight (55%) and overweight or obese individuals (52%), and those with 2 h/d (47%) and more than 2 h/d of television or video watching (50%). Engaging in PA less than recommended levels was also related to a reduced mortality risk (19%) [119]. The findings of these studies seem to suggest a dose-response relation between PA and all-cause mortality, independent of other risk factors. These studies also support the idea that moving those who are sedentary to the recommended PA levels should be considered as a public health priority.

Since the 90's research on the benefits of PA has extended to multiple risk factors and to dose-response issues.

Strong evidence indicates that PA substantially reduces the risk of type 2 Diabetes. Randomized trials have shown that PA alone or in conjunction with dietary changes can reduce the incidence of type 2 Diabetes [69, 70, 120, 121]. Observational studies have consistently reported an inverse association between PA and type 2 Diabetes, but most of these studies focused on vigorous activities or PA of various intensities combined [122, 123]. In a recent systematic review, Jeon et al (2007) found that the summary relative risk of type 2 Diabetes was 0.69 (95%CI:0.58-0.83) for regular participation in moderate PA when compared to be sedentary. Similarly, the relative risk was 0.70 (95%CI:0.58-0.84) for regular walking (typically≥2.5 h/week of brisk walking) when compared with almost no walking. The associations remained significant after adjustment for BMI. Similar associations were observed in men and women and in the U.S. and Europe [124].

Systematic reviews of the relations between PA and hypertension have suggested a reduction of around 3 mmHg in systolic blood pressure and 2 mmHg in diastolic blood pressure among the most active [125-128] . Kelly et al (2001) in a meta-analysis also found a statistically significant decrease of

approximately 2% in both resting systolic and diastolic blood pressure (systolic, mean -3±1 mmHg, 95% CI:-5 to -2 mmHg; diastolic, mean -2±1 mmHg, 95%CI:-3 to -1 mmHg) with higher walking levels [128]. Data from the CARDIA Study with 3 993 young men and women found that those who were more physically active versus less physically active experienced a reduced risk (hazard rate ratio=0.83; 95%CI:0.73-0.93) of the incidence in hypertension, after adjustment for race, sex, age, education, and family history of high blood pressure. [129].

In large population studies, higher PA levels are related with a more favourable lipid profile, i.e. lower levels of total cholesterol [130-132], Low Density Lipoprotein cholesterol (LDL-C) [130, 131, 133], triglycerides [130-132], and apolipoprotein B and higher levels of High Density Lipoprotein cholesterol (HDL-C) [130, 132, 133] and apolipoprotein A1 [130, 131]. Recently, Tambalis et al (2008) in a review of randomized control trials, review studies and original papers, noticed that the most frequently observed alterations related to higher PA levels were reductions in triglycerides, total cholesterol, and LDL-C appeared less often. Furthermore, the evidence of the positive effect of resistance exercise marks out a trend mainly for the LDL-C levels, whereas for combined exercise (aerobic with resistance), results showed improvements in values of both the HDL-C and the LDL-C. High-intensity aerobic training results in improvement of HDL-C [134]. In a 7 years longitudinal study (the CARDIA study) a decrease in fitness during young adulthood was associated with unfavourable changes in lipid profile, explained mostly by increased weight [135]. Conversely, in a meta-analysis Kelly et al (2004) found statistically significant, walking-induced decreases of 5% and 6% in LDL-C and total cholesterol/HDL-C ratio (LDL-C, mean=-5.5±2.2 mg/dL, 95% CI:-9.9 to -1.2 mg/dL; total cholesterol/HDL-C ratio, mean=-0.3±0.1, 95% CI:-0.6 to -0.1). No statistically significant changes were observed in triglycerides, HDL-C or total cholesterol ($p>0.05$), although changes were in the direction of benefit. The authors concluded that walking reduces LDL-C and total cholesterol/HDL-C ratio in adults independent of changes in body composition [136].

PA is also associated with a reduction in the overall risk of cancer. Several reviews have shown a protective effect of PA on the risk of colon

cancer [137]; breast cancer specially among postmenopausal women [138]; endometrial cancer [139, 140] and ovarian cancer [141]. A systematic review of more than 100 epidemiologic studies showed that physically active men and women have around 30-40% reduction in the risk of developing colon cancer, compared with inactive persons. Although data are sparse, it appears that 30-60 min./day of moderate to vigorous PA is needed to decrease the risk. It seems to be a dose-response relation, with risk declining further at higher levels of PA. It is also clear that PA is not associated with the risk of developing rectal cancer. With regard to breast cancer, there is reasonably clear evidence that physically active women have around 20-30% reduction in risk, compared with inactive women. It also appears that 30-60 min./day of moderate to vigorous PA might be needed to decrease the risk of breast cancer, and that there is likely a dose-response relation. Concerning prostate cancer, the data are inconsistent regarding whether PA plays any role in its prevention. There are relatively few studies on PA and lung cancer prevention. The available data suggest that physically active individuals have a lower risk of lung cancer; however, it is difficult to completely account for cigarette smoking. Finally, this review stated that there is little information on the role of physical activity in preventing other cancers [142].

Participation in PA throughout life can increase and maintain musculoskeletal health, or reduce the decline that usually occurs with age in sedentary people. Indeed, osteoporotic fractures are a debilitating and frequently fatal health problem for older adults and a growing body of evidence indicates that osteoporosis has its origin in early life and that the level of development of bone mass during childhood and adolescence strongly influences the risk for osteoporotic fractures [143]. Early investigators showed a strong relation between muscle and bone, especially in athletes and others who exercised regularly [144]. Mechanical loading of sufficient intensity promotes an increase in skeletal mass, especially during growth in the first 2 decades of life [144]. Weight-bearing exercise, particularly resistance exercise, seems to have the greatest effects on bone mineral density. One review with several cross-sectional reports showed that people who did resistance training had increased

bone mineral density compared with those who did not do such training. Moreover, athletes engaged in high-impact sports tended to have increased bone mineral density compared with athletes engaged in low-impact sports[145]. In a meta-analysis of randomized control trials, by Wolf et al (1999) showed very consistently, in both pre and post menopausal women, that exercise training programs were found to prevent or reverse about 1% of bone loss per year in the lumbar spine and femoral neck [146]. Exercise training appears to significantly reduce the risk and number of falls, similarly the risk and incidence of fractures is also reduced among active people[147]. Vouri et al (2001) in a review about the dose-response of PA and low back pain, osteoarthritis, and osteoporosis, found that PA can be effective in preventing low back pain but prolonged heavy loading can lead to low back pain. No evidence indicates that PA directly prevents osteoarthritis, in fact large amounts of intensive PA involving high impacts, torsional loadings or causing injuries increase the risk of osteoarthritis. Light or moderate PA does not seem to increase the risk of osteoarthritis and PA may be effective in the treatment and rehabilitation of osteoarthritis. On the other hand, high-intensity loading is osteogenic and possibly useful in prevention of osteoporosis at the loaded site, but low to moderate loading is not osteogenic [148].

One of the benefits of PA is psychological well-being. Several reviews have identified positive relations between PA and a better mental health [149]. However, these reviews did not specifically examine the association between PA dose, domain or setting, which is particularly important for the purpose of public health recommendations [149], once depression is the leading cause of disability in the developed world [150] and it is estimated that by the year of 2020 depression may be the second leading cause of disability, next to CVD in the developing countries [151]. Only recently in a review performed by Teychenne at al (2008) these issues were considered and the evidence suggests that even low doses of PA (less than the recommended 30 min/day of moderate PA) may be protective against depression or symptoms of depression; however, this review further emphasizes the fact that few clear conclusions can be drawn regarding the optimal dose, domain and setting of PA in reducing the likelihood

of depression, remaining several major gaps in the research area of PA and depression [149].

As stated above the aetiology of overweight and obesity is clearly multifactorial, but ultimately it is determined by the long-term imbalance between energy intake and expenditure. Low levels of PA are a significant factor in the dramatic increase in obesity prevalence in the European Region [102]. A number of cross sectional studies have found negative relations between PA and people's body weight [152-159]. In a representative sample of 15 member states of the European Union, Martinez-Gonzalez (2001) estimated cross-sectional associations between leisure time PA and weight status. After controlling for gender, age, recent weight change, education level, social class, marital status, country of origin and smoking, the authors found that individuals in the highest quintile for leisure time PA were approximately 50% less likely to be classified as obese (BMI≥30 kg/m^2) than those in the lowest quintile [160]. In 2000, Fogelholm & Kukkonen-Harjula have systematically reviewed the literature describing data from observational cohort studies and randomized control trials of PA and weight gain in adults, and concluded that there is inconsistent evidence of the predictive effect of baseline PA on subsequent weight gain. However, the authors observed that the association between weight gain and change in activity or activity at follow-up is stronger, although still modest [161]. According to Wareham et al (2005) [162] the Fogelholm & Kukkonen-Harjula (2000) results might be interpreted in three different ways: (a) PA is an important factor in preventing weight gain, but the true association is not detectable because of measurement error; (b) less weight gain leads to better exercise adherence; a reverse causality argument; (c) the self-reported PA may be a proxy for a general healthy lifestyle; a confounding argument. In 2005, Wareham et al. updated the review by Fogelholm & Kukkonen-Harjula (2000), the authors found that in most of the longitudinal studies (9 in 12), lower self-reported PA was predictable of higher subsequent weight gain; one study, however, reported a reverse association, implying that higher baseline BMI predicted future low PA levels and two studies did not find an association. It is likely that the larger samples of the studies included in the Wareham's review

could have the power to detect small associations; alternatively it is possible that the predominance of recent studies in the expected direction could manifest publication bias, once the plausibility of the association between the lack of PA and weight gain, as well as the widespread public view that lack of PA is driving the current obesity epidemic, publication bias is possible [162].

Regarding walking, some longitudinal [163] and cross-sectional studies [164, 165], and randomized controlled trials [166] have described negative relationships between BMI and walking, others pointed-out that these associations are not linear [167] and the negative association between PA and BMI is restricted to vigorous rather than moderate-intensity activities [168]. While, moderate PA may be adequate to decrease cardiovascular risk factors and mortality [169], it may not be sufficient for weight control [168]. Guo et al (1999) also demonstrated that higher PA levels were required to preserve fat free mass and reduce body fat with aging [170]. It is also known that obese individuals may benefit more from their walking time than normal weight participants. For instance, Hills et al (2006) demonstrated that in spite of walking slower, obese individuals had a more intense physiological response than normal-weight counterparts even if they "walked for pleasure" (more 15 beats per minute), which equated with an exercise intensity that is sufficient to improve cardio respiratory fitness in obese, but not in normal-weight [171]. Browning et al (2005) also showed that walking was 11% more calorically expensive for obese women compared to normal weight ones, when done at similar speeds, which may imply a greater cardiovascular effort for the obese [172].

Both obesity and physical inactivity are important risk factors for coronary heart disease, hypertension, dyslipidemia, type 2 Diabetes and certain types of cancer [98-100, 173] and have a direct relation to premature mortality [93, 97, 111] and health related quality of life [92, 174-176]. When the impact of a sedentary lifestyle is coupled with poor diet, the Centers for Disease Control and Prevention estimate that an extra 400 000 lives may be lost per year, putting these lifestyle issues just behind smoking as a leading cause of death in the United States [177].

Since the 70's, several international organizations have developed PA guidelines for healthy adults. These guidelines have significantly changed in the

past years and, since 2007, the ACSM/AHA PA guidelines recommend the accumulation of 30 minutes or more of moderate-intensity aerobic PA five days per week or 20 minutes of vigorous-intensity aerobic PA three days per week [178].

The term Health–enhancing Physical Activity (HEPA) is frequently used across the European Region. It emphasizes the connection to health by focusing on "any form of physical activity that benefits health and functional capacity without undue harm or risk" [179].

Despite the benefits of regular PA on health, the prevalence of the population that comply with the recommended levels of PA is undesirable in many developed countries [180, 181]. It is estimated that in the WHO European Region, one in five people takes little or no PA, with higher levels of inactivity in the eastern part of the Region [5]. In 2006, data from the Eurobarometer Study showed that only one-third of the adult European population (29.8% in women and 36.9% in men) achieved the HEPA category; and data for Portugal showed similar results [182]. More recently, a WHO 51 country survey showed that, throughout the world 15.2% of men and 19.8% of women exhibits low PA levels (i.e. do not comply with the 2007 PA guidelines), and that, within the European region, Turkey (29% for men and 43.5% for women) and Spain (27.5% for men and 32.9 for women) showed the highest prevalence of low PA levels [183]. Similarly, data from the BRFSS in the USA show that 48.8% of the American complies with the recommended PA levels of the 2007 guidelines and that 13.5% are inactive (no PA) [184]. Regarding leisure time PA, some studies have indicated that Portugal has one of the lowest PA prevalence in Europe [7, 159, 160]. About 70% of the adult Europeans living in the European Union (15 countries) practice some kind of leisure time PA [160]. In a European Union 15 countries study, Varo et al (2003) found that only 10% of the Portuguese population spend more than 10% of their leisure time in activities involving an expenditure of 4 MET. In this study, the authors also found a north-south gradient in the leisure time PA prevalence, with the northern countries of the European Union (Sweden, Ireland, Austria, The Netherlands and Finland) showing a higher

prevalence of leisure time PA than the Mediterranean countries (Portugal, Spain, Greece and Italy) [159].

Among the possible PA, walking is regarded as one of the most popular leisure time PA pursuits in USA [185, 186] and in Europe [155], is a feasible way of travelling, a virtually cost free type of PA and is related to several health benefits [136, 187-190]. Interventional and longitudinal studies have shown that walking may decrease the risk of diabetes [187], improve lipid profile [136] and cognitive function [188], have a favourable effect on body fat and body mass gain [189] and reduce cardiovascular risk [190]. Additionally, "brisk" walking appears to meet the minimum intensity recommended to achieve cardio respiratory benefits in unfit populations [191]. Cross-sectional studies have also shown positive associations between walking and health related quality of life [192]. Moreover, walking as a way to get to and from places or as a way of recreation or exercise may contribute significantly to adults' total PA [186, 193, 194] and provides a feasible method of integrating PA into modern lifestyles. Walking, as any other form of moderate PA, can be more readily adopted and maintained throughout the lifetime than vigorous PA [101]. Some research did not found significant associations between walking levels and age [182, 193], gender [182], education level [182, 195] and BMI [193], highlighting the acceptability and accessibility of walking among subjects from all strata. Nevertheless, some studies showed positive associations between walking, male gender and education level [196]; Hagstömer et al (2006) [195] demonstrated an inverse relation between walking and BMI as well as a positive association between walking and age; Cole et al (2006) [193] found positive associations between walking and education level. These similarities and differences may suggest culture and social diversity in samples.

Information on temporal PA trends may identify population subgroups at high risk for physical inactivity, evaluate public health interventions, improve the understanding on dose-response issues, and help develop specific population PA interventions [197]. Several countries have documented the temporal trends of participation in PA. It seems that, in the past two decades, in the UK [198], in the USA (Minnesota) [199], in Spain [200, 201] and in Finland [202, 203] the increased

prevalence of leisure time PA has been counter-balanced by a decrease in occupational PA and in active commuting; in the UK Study no temporal changes were found for total PA [198]. Data from Canada also showed that leisure time PA has increased between 1981 and 2000 [204]. On the other hand, data from a prospective study, in Swedish women, revealed a substantial decrease in total PA in the last six decades [205]. Similarly, Bauman et al (2003) showed that between 1997 and 1999 the national participation in sufficient total PA declined from 63% to 57% among Australians, although the knowledge about benefits of moderate PA increased in the same period of time [206]. In the USA, the Behavioral Risk Factor Surveillance System presented a decrease in the prevalence of leisure-time physical inactivity (from 30% to 24%) from 1994 to 2004 [207].

The accurate measurement of PA is essential in the epidemiological study of the relations between health and PA as well as for the recommendation of an appropriate pattern of PA to maintain good health [208]. PA is not simple to assess because it is a complex multi-dimensional behaviour. PA occurs in a variety of different domains, i.e. in transportation, domestic life, occupation and recreation. In addition to the different domains, PA assessment needs to consider intensity, frequency, duration and the type of activity undertaken [162]. In studies with a small number of participants PA can be determined with very precise and direct instruments like direct calorimetry, doubly labelled water, motion sensors, accelerometers, heart rate recorders or oxygen consumption [208]. But, due to feasibility and economic costs, most of the epidemiological studies have used questionnaires. Every method to measure PA has advantages and weaknesses. For example, the accuracy of the direct methods may not be sufficient in studies where it is necessary to discriminate the types of PA or to know the context where PA are performed. In this case, the use of other methods as complement is required, namely questionnaires. And, despite the advantages of using direct methods, these types of measures are often cost and time intensive and intrusive rendering them difficult to apply to large epidemiologic settings [209]. These measures also require specialized training and the physical proximity of the participant for data collection [209]. There are

several questionnaires to measure PA in the adult population that vary greatly in detail, period of survey and the extent of supervision of the respondents. Some questionnaires may examine PA in the last one to seven days, through last month and the entire lifetime [208]. Questionnaires rely on the respondent perception, interpretation, memory, age, education level, length of the period surveyed and cultural factors [208] and therefore might not be as accurate as other direct instruments. Moreover in general, questionnaires tend to overestimate the time and intensity of PA [210-212], particularly in women and in overweight/obese subjects [213]. Nevertheless, PA questionnaires are cheaper, friendly and convenient for the participants, easier to administer and, more reproducible than other methods. PA questionnaires are one of the most cost-effective methods assessing PA and therefore they are appropriate to use in large-scale population studies [200]. Recently, Prince at al (2008) systematically reviewed the literature on comparison of direct versus self-reported measures for assessing PA in adults, and found no clear trends in the over-or underreporting of PA by self-report compared to direct methods and even though it seems to exist a pattern of agreement between self-reported and direct methods they are likely to depend on the direct methods used for comparison, as well as on the gender of the population sample. Compared with direct measures, self-report methods appear to estimate greater amounts of higher intensity (i.e. vigorous) PA than in the low-to-moderate levels. This review also showed that many of the studies analysed the relationship between self-report and direct measures by using a correlation coefficient, which is limited, as correlation only measures the strength of the association between two variables and cannot calculate the level of agreement between them, unlike other statistical procedures such as the Bland & Altman Plots.

Although several studies from different countries have documented PA levels of the adult population, comparison between studies is somewhat difficult, given the variety of methods used to measure PA (namely different questionnaires) and the PA domain assessed. Conversely, leisure time PA has been one of the most frequently assessed domains of PA, but, current PA guidelines for adults emphasize total PA, not only leisure time PA. Indeed,

studies that assess only leisure time PA under-represent peoples' PA. This may be of importance, particularly in developing societies, where occupation PA and housework PA may typify a substantial proportion of men's and women's total PA, respectively. In an Irish study, with the Institute of Public Health PA questionnaire, Livingstone et al (2001) showed that men can be twice as active in occupational and leisure time activities, while women are three times more active in household pursuits [214]. International Physical Activity Questionnaire (IPAQ) [215] was developed to overcome some of the limitations of other PA questionnaires, i.e.: a standardized questionnaire, translated into different languages, which covers all the PA domains and therefore allows comparisons between studies and populations as well as global surveillance [216]. IPAQ reports separately vigorous-intensity PA, moderate-intensity PA and walking in terms of frequency and duration of each specific type of activity, during the last seven days. This instrument also reports the time spent sitting in an ordinary week day. Both categorical and continuous indicators of PA are possible from the IPAQ. Validity and reliability data from 12 countries (including Portugal) showed that IPAQ has comparable validity and reliability to CSA monitor and to other self-reported measures of PA [216].

A better understanding of the prevalence and correlates of PA is particular important to design and implement programs to promote PA, once adults' participation in PA is influenced by a diverse range of personal, social, and environmental factors.

The two most consistent demographic correlates of PA are age and gender. It has been widely reported that men achieved the highest PA categories more frequently than women, regardless of the method used to measure PA or the domain of PA assessed [101, 160, 180, 181, 183, 195, 214, 217, 218]. Although, in the 51 country WHO PA survey women living in the Eastern European countries of Croatia, Hungary, the Czech Republic, Kazakhstan, the Russian Federation, Slovakia, and the Ukraine were more likely to be active than men [183]. Several studies also indicate that total PA or leisure time PA are inversely associated with age [159, 218-220].

Socioeconomic status, education level and occupation are frequently positively associated with leisure time PA [154, 159, 221-223]. However, when total PA is considered, the relation between socioeconomic status, education level or occupation is often a negative one [154, 223, 224]. For instance, with the IPAQ - IPS-Sweden study, Bergman et al (2008) showed that subjects in the highly total PA category were 50% less likely (OR=0.5;95%CI:0.3-0.9) to have a college/university degree when compared with the less active [224]. Nevertheless, Sjöström et al (2006) in the IPAQ-Eurobarometer study did not found a significant relation between education level and total PA [182]. Others have also showed that blue-collar employees who perform higher rates of work-related PA usually exhibit lower rates of leisure time PA[225]. Actually, it is possible that the least educated or with lower income perform more physical demanding jobs.

Literature has produced mixed results about the association between marital status and PA [218]. But, some authors hypothesize that time pressures of juggling career and family responsibilities have a great impact on women and reduce significantly their leisure-time [226, 227].

Among the psychological, cognitive and emotional correlates of PA, in a review by Trost et al (2002) PA self-efficacy (a person's confidence in his or her ability to be physically active on a regular basis) emerged as the most consistent correlate of PA behavior[218]. For example, Sternfeld et al. (1999) examined the correlates of PA in an ethnically diverse sample of 2636 American women and find out that women with high levels of PA self-efficacy were two and four times more likely to be in the highest quartile for PA than were those with low levels of self-efficacy [228]. Another important correlate within the psychological, cognitive and emotional correlates of PA, in both men and women, are the barriers for PA (lack of time, tiredness, weakness, fear of falling, bad weather, lack of facilities or exercise partners), specially leisure time PA [218]. Trost et al (2002) also found that knowledge related to health and PA was not associated with PA [218].

Social and cultural factors like social support are also likely to correlate with PA levels [218]. For example, in an Australian study with college students, from both genders, those who reported low levels of social support were 23-

55% more likely to be insufficiently active compared to those in the highest PA category [229].

Among the behavioural attributes and skills, past exercise behaviour, healthy diet and not smoking seem to be predictors of current PA [159, 160, 218].

Traditionally, the research of the correlates of PA has focused on the individual determinants but the last 10 to 15 years research has paid particular attention to the environmental factors related to PA. Indeed, from an ecologic point of view, PA behaviour can be seen as a result of an interaction between personal attributes and environmental factors [230]. Research in this field has focused on availability and proximity of facilities for exercise and recreation [231], physical features of the environment, neighbourhood safety, aesthetics and social organization of communities [232]. Several cross-sectional studies have identified positive relations between total PA and perceived or objectively measured [231, 233] activity-friendly environmental characteristics.

Research using self-reported measures of environmental attributes, has shown positive associations between total PA and access to facilities for exercise [233-236], existence of sidewalks [233, 235] and bike paths [235, 237], social support [238, 239] and access to shops and services [233, 237]. King et al [221] also demonstrated that observing others being active in the neighbourhood was positively associated with PA.

In a recent review of self-reported and objectively measures of environmental determinants of PA, Wendel-Vos et al (2007) found that social support showed to be positively associated with total PA in 58% of the studies, in both genders; regarding sedentary behaviour and moderate PA levels most of the studies showed null associations, others showed positive and others negative associations, therefore no statement can be made on the potential environmental determinants of these behaviours; convincing evidence for a positive association was found for vigorous PA or sports participation and availability of PA equipment and social support, and a possible association for convenience of recreational facilities; based on this review no potential differences between genders can be stated for vigorous PA or sports participation and environmental determinants; when moderate and vigorous PA

(MVPA) were combined, convincing evidence was found for social support and having a companion for PA, in both genders; with regard to MVPA, possible associations were noted for accessibility of recreation facilities, convenience of recreational facilities and availability of trails, and no gender differences could be stated; connectivity of trails was convincingly associated with commuting activities, but again no statement can be make on possible gender differences; no convincing or possible environmental determinants of bicycling were determined; having a companion and social support were convincingly and positively associated with walking behaviour, although no information allowed the study of gender differences; a possible positive association was reported for availability of sidewalks among men but not in women; environmental aesthetics did not appear as a convincing or possible environmental determinant of total walking or walking in the neighbourhood, nevertheless, when studies report results by gender, aesthetics may be a potential determinant of walking in general or walking in the neighbourhood among men, but not among women [240]. It is important to notice that in the review by Wendel-Vos et al (2007) of the 47 studies only 3 were longitudinal studies and the results of these studies did not differ from the cross-sectional ones.

Few studies have examined gender differences in the relation between PA and perceived environmental attributes**.** Using the Environmental Module of the International Physical Activity Prevalence Study questionnaire on perceived environmental attributes, in a sample of Canadian adults, Bengoechea et al. [241] showed that social support was a significant predictor for leisure time PA in women; aesthetics was associated with leisure time PA in men and access to places for PA in both genders, although no significant relationships were found among women after adjustment for self-efficacy. Foster et al. [242] reported, in English adults, that men's walking ≥150 min/week was associated with access to a local park, whereas women's walking was related to access to shops and safety during the day. Understanding differences between genders may be especially important because women systematically show lower PA levels.

Literature has also identified positive relations between walking for particular purposes and activity-friendly environmental features [243]. Research

using perceptions of environmental attributes and self-reported total walking has shown positive associations between higher total walking levels and presence of sidewalks [237, 244, 245] or walking trails [244]; number of walking routes [246]; high residencial density [237]; enjoyable scenery [244] or attractive open spaces [247]; awareness of places to walk and convenience of the walking place [248]; access to a local park [242, 246]; access to shops [237]; car parking difficulty (availability of parking spaces or its costs) [249] and social support [244] or having physically active neighbours [245]. In 2004, a review by Owen et al. found that convenience of facilities for walking and accessibility of destinations (such as convenience of biking or walking trails, stores in walking distance) were associated with total walking [243].

Literature about perceived safety and PA or walking is inconsistent and to date the evidence is insufficient to conclude that crime-related safety influences PA [250].

Recently, literature on the environmental correlates of PA has considered the question about the agreement between perceived and objectively measured environmental characteristics. Some studies have shown a mismatch and low levels of agreement between perceived and objective measures of the environmental characteristics, namely on hills, weather, PA facilities, walking/bicycle tracks and tennis courts, especially in younger and older women, those with low income, with low self-efficacy for PA, those who are less active and who have lived for less than 2 years in the neighbourhood [251] [252]. This issue is of particular importance and has several practical implications for researchers and practitioners, because the associations between objective measures of environment and PA might not be meaningful to design and implement strategies to PA promotion and these strategies may not result in desirable behavioural changes, if individuals perceptions differ from reality and if these perceptions inhibit activity [253].

Thus, perceptions of environmental attributes may be influenced by several lifestyle behaviours, personal beliefs and cultural values and consequently affect people's PA behaviours [251]. Other studies found that objective measures of environment do not match with environmental

perceptions because people tend to judge the environment according to their own desires and expectations [254]. On the other hand, it is also possible that some objective measures of the environment correlate with PA behaviour even if people do not perceive them, and if so, strategies to PA promotion should also consider those environmental features.

Although the evidence of the relation between PA or walking and environment is growing, most of the research has been carried out in US and Australia. Consequently, studies in other settings are necessary, once it is not clear whether the associations, observed in those countries, are generalizable to other populations [255]. Indeed, the limited variability of environmental attributes where the studies have been conducted is one of the limitations of this research area [237].

The need to increase PA levels in a population basis is considered a public health priority [256]. Therefore, to design and implement relevant policies and effective programs, it is essential to identify which set and environmental features provides potential opportunities for PA in general and/or for walking in particularly, once changes in the environment may affect a large number of people on a relatively permanent basis. In the context of the public health goal to increase regular moderate PA, the most relevant behaviour is walking, once public health policy literature has identified walking as the PA behaviour of adults that should be the most amenable to influence [243] .

Despite the importance of these issues for public health prevention strategies, studies in the Portuguese adult population are few and, to the best of our knowledge, there are no data regarding the Azorean population.

The Azorean Archipelago - Portugal, in the North Atlantic, comprises nine islands with a population of 240 024 people [257]. Azores is one of the seven "outermost regions" of the European Union [258] and has some unique geographical features and urban design that differ from the mainland. All of the islands have volcanic origins, numerous landscapes with virgin forest and green fields. Most of the urban areas are small and located in the coast. Tourism, fishing and agriculture are the most important occupations.

2. Aims

2. Aims

The overall aims of this thesis were to describe the prevalence and to examine the relations between some of behavioural (physical activity, tobacco use and alcohol consumption, sleep duration, meal frequency) biological (overweight/obesity) and societal factors (environmental characteristics and socio-economic status), in a large sample of Azorean adults.

This thesis presents five distinct papers, each based on specifics aims:

Paper I - **Santos, R.**; Aires, L.; Santos, P.; Ribeiro, J. C. & Mota, J. **Prevalence of overweight and obesity in a Portuguese sample of adults: results from the Azorean Physical Activity and Health Study.** ***Am J Hum Biol 2008*****;20(1):78-85.**

(i) to determine and compare the obesity status

(ii) to explore social and behavioural factors associated with obesity in Azorean adults.

Paper II - **Santos, R.**; Santos, M.P.; Ribeiro, J. C. & Mota, J. **Physical Activity and Other Lifestyle Behaviors in a Portuguese Sample of Adults: Results from the Azorean Physical Activity and Health Study.** ***Journal of Physical Activity and Health (in press)***

(i) to describe PA prevalence and compare it with other countries

(ii) to investigate possible associations between physical activity and other lifestyle behaviours, in Azorean adults.

Paper III - **Santos, R.**; Pratt, M.; Ribeiro, J.C.; Santos, P. M.; Carvalho, J. & Mota, J. **Walking and Body Mass Index in a Portuguese Sample of Adults: Results from the Azorean Physical Activity and Health Study.** ***(submitted)***

(i) to investigate the cross-sectional associations between walking and body mass index.

Paper IV – **Santos, R.**; Silva, P.; Santos, P.; Ribeiro, J. C. & Mota, J. **Physical activity and perceived environmental attributes in a sample of Portuguese adults: Results from the Azorean Physical Activity and Health Study.** ***Prev Med*** **2008;47(1):83-8.**

(i) to determine whether perceived neighbourhood attributes were associated with reported PA levels in Azorean adults, by gender and BMI categories.

Paper V – **Santos, R.**; Vale, S..; Miranda, L. & Mota, J. **Socio-demographic and Perceived Environmental Correlates of Walking in Azorean Adults.** ***(submitted)***

(i) to describe walking patterns

(ii) to examine associations between socio-demographic characteristics and perceived environmental attributes with walking among Azoreans.

3.Methods

3. Methods

3.1. Study Design and Sampling

Data for the present thesis derived from the Azorean Physical Activity and Health Study (APAHS) a cross-sectional study carried out by the Azorean Government with the collaboration of our Research Centre. The APAHS main objective was to examine PA patterns, obesity status, environmental correlates of PA and obesity and other lifestyles characteristics of the Azoreans, in order to design and implement interventions aimed to increase PA levels in the adult population.

Data were collected in the spring of 2004. This study was conducted according to the guidelines of the Helsinki Declaration of Human Studies. Data collection was accomplished by mailing questionnaires to the adult residents. The questionnaires were sent through school children to their parents or relatives aged 18 or older. The potential sample included 16 000 adults (≥ 18 years old) from 7 500 households. Participants received an information letter asking them to participate in this survey. A response rate of 87.6% (14 017 questionnaires) was obtained.

Individuals who did not meet the age criterion (18 - 65 years) were excluded, as well as those whose questionnaires contained a majority of missing information or were repeated (n=3 985). Pregnant women were also deleted from the analysis (n=41).

The sample for papers I, II and III included 9 991 adults (5 723 women and 4 268 men) aged 37.78±9.45 years. The sample for paper IV and V included 7 330 (4 104 women and 3 226 men) aged 38.1±9.3 years.

3.2. Measures

The questionnaire included several demographic, social and behavioural variables and anthropometric measures.

3.3. Anthropometric Measures

BMI was calculated from self-reported weight and height and used to evaluate weight status according to WHO recommendations. BMI was divided in three categories: normal weight (18.5 kg/m^2 ≥ BMI <25 kg/m^2); overweight (25 kg/m^2 ≥ BMI < 30 kg/m^2) and obese (BMI≥30 kg/m^2) [10].

3.4. Walking, Physical Activity and Sitting Time

Walking, MVPA, total PA and sitting time were assessed using the short "last week" version of the IPAQ [259].

IPAQ reports separately vigorous-intensity PA, moderate-intensity PA and walking in terms of frequency and duration of each specific type of activity, in the last seven days. This instrument also reports the time spent sitting in an ordinary week day. Both categorical and continuous indicators of PA are possible from the IPAQ short version.

Validity and reliability data from 12 countries (including Portugal) showed that IPAQ has comparable validity and reliability to CSA monitor and to other self-report measures of PA [259].

Cleaning data and out-of-range values, as well as data analysis were done in accordance with the International Consensus Group on Physical Activity Measures. According to the Guidelines for data Processing and Analysis of the IPAQ [215], in papers I,II and IV total PA was expressed in MET-minutes/week (metabolic equivalent), by weighting the reported minutes per week, in each activity category, by the metabolic equivalent specific to each activity (Total PA = 3.3 METs x walking minutes x walking days + 4.0 METs x moderate-intensity activity minutes x moderate days + 8.0 METs x vigorous-intensity activity minutes x vigorous-intensity days). Subjects were then classified in three categories according to their level of PA:

(i) Category 1 - is the lowest level of PA, individuals who did not meet the criteria for categories two or three are considered to have a "low PA level";

(ii) Category 2 - the minimum pattern of activity to be classified as "moderate PA level" meets any of the following three criteria: a) three or more days of vigorous activity of at least 20 minutes per day; b) Five or more days of moderate-intensity activity or walking at least 30 minutes per day; c) Five or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving at least 600 MET-minutes/week.

(iii) Category 3 – HEPA active (Health-Enhancing Physical Activity) - is a more active category, computed for people who exceed the minimum public health physical activity recommendations. The IPAQ scientific group proposes this new cut point, which equates to approximately one hour of total activity per day, of at least moderate-intensity activity. The minimum pattern of activity to be classified as "HEPA Active" meets any of the following two criteria: a) vigorous-intensity activity on at least three days achieving a minimum of 1500 MET-minutes/week; b) 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving at least 3000 MET-minutes/week.

In papers II, III and V, walking, MVPA and Total PA were expressed as minutes per week.

In paper II, total PA was also expressed in minutes per week, by summing the time spent in moderate PA and vigorous PA, to determine the proportion of the sample that meets the ACSM/AHA PA guidelines [178]. Subjects were classified in three categories according to their level of PA in min/week: inactive (participants who reported no PA/week); insufficiently active (participants that reported less than 150 min/week of at least moderate-intensity PA or less than 20 min/week of vigorous-intensity PA) and sufficiently active (participants that reported 150 min/week or more of at least moderate-intensity PA or 20 min/week or more of vigorous-intensity).

In paper III, total PA was computed by multiplying the reported minutes of moderate and vigorous PA (excluding walking) by the number of PA days. Walking was also computed by multiplying the reported minutes per week of walking by the number of walking days. Participants were divided in three groups according to tertiles of walking.

In papers V, MVPA was computed by summing the reported minutes per week of moderate and vigorous PA, excluding walking. Total PA computed by summing the reported minutes per week of MVPA and walking. Participants were classified as never walkers (no walking in the previous week); occasional walkers (walking for at least 10 min/week but less than 150 min/week); and, regular walkers (walking for 150 min/week or more).

Sitting time was expressed in minutes per day. The time spend sitting in an ordinary week day was considered a proxy measure of inactivity [182, 195]. In paper I,II participants were divided in two categories according to the median value: group 1 (< 3 hours/day) and group 2 (≥ 3 hours/day) [215].

3.5. Socio-economic Status

Education level, personal income per month and occupation were collected.

Education level was collapsed into four groups in accordance to the Portuguese Educational System: group 1 (4 years' education); group 2 (5-9 years' education); group 3 (10-12 years' education) and group 4 (higher education).

Subjects were categorized in six groups according to their personal income per month: group 1 (< 500 euros); group 2 (500 - 875 euros); group 3 (875 - 1250 euros); group 4 (1250 - 1625 euros); group 5 (1625 - 2000 euros) and group 6 (> 2000 euros).

Occupation was labelled according to the Portuguese National Institute of Statistics [260].

For the purpose of paper I, a six-point scale was recoded for occupation (occupational score), according to the mean PA level of each occupation group – from manual workers (lower values) to executive workers (higher values). The Socio-economic status (SES) index variable was obtained by multiplying the education level (ranging from 1 to 4) of each individual with their personal income per month (ranging from 1 to 6) and occupation score (ranging from 1 to

6). The SES index (education level x personal income per month x occupation score) ranged from 1 to 144 was divided into tertiles (first tertile: < 9; second tertile: 10 - 20; third tertile >21). Similar procedure described elsewhere [28].

3.6. Smoking

Participants were classified as non smokers, former smokers (individuals who had stopped smoking for at least six months), occasional smokers (individuals who smoked less than one cigarette a day) and current smokers (individuals who smoked at least one cigarette a day) [261]. Occasional smokers were recoded and combined with current smokers due to their small sample size.

In paper V, Occasional smokers were combined with current smokers as coded as smokers; non smokers were combined with former smokers and coded as non smokers.

3.7. Alcohol Consumption

Participants were classified as non drinkers (no alcohol for more than twelve months), former-drinkers (no alcohol for more than six months), occasional drinkers (individuals who drank less than one unit per week), regular drinkers (individuals who drank one to 10 units per week) and heavy drinkers (individuals who drank more than 10 units per week) [262]. Former-drinkers were recoded and combined with non drinkers; heavy drinkers were recoded and combined with regular drinkers, due to their small samples sizes.

In paper V, former drinkers were combined with non drinkers and coded as non drinkers; heavy drinkers, regular drinkers and occasional drinkers were combined and coded as drinkers.

3.8. Perceived Environmental Attributes

To assess perceived neighbourhood environments we administered the Environmental Module of the International Physical Activity Prevalence Study questionnaire [263].

The questionnaire has 17 questions about residential density; access to destinations; neighbourhood's infrastructures; aesthetic qualities; social environment; street connectivity; neighbourhood safety and number of household motor vehicles. The question about residential density has 6 response options: detached single-family housing; Townhouses, row houses, apartments or condos of 2-3 stores; Mix of single-family residences and townhouses, row houses, apartments or condos; Apartments or condos of 4-12 stores; Apartments or condos of more than 12 stores; and don't know/not sure. One question asked about how many motor vehicles there were at the household. The other 15 questions have a four-point Likert response scale: strongly disagree; somewhat disagree; somewhat agree; strongly agree and don't know/doesn't apply response option.

This questionnaire has been used previously and shown good reliability. [234, 264, 265].

3.9. Lifestyle Variables

(i) Sleep Duration - Based on participants' sleeping hours per day, individuals were classified in three groups: group 1 (< 7hours/day); group 2 (7-8 hours/day); group 3 (> 8hours/day) [266].

(ii) Marital Status - single/never married; married/partner and separated/divorced/widowed.

(iii) Number of Children per person - none; one child; two children and three or more children.

(iv) Meal Frequency - Daily Meal Frequency was assessed by the question: How many meals per day do you consume? The main meals

represented meals that were conventionally served on a plate [267]. For statistical analysis the participants were grouped in three meal frequency categories: three or fewer; four and five or more.

3.10. Statistical Analysis

All statistical analysis were performed using SPSS 14.0 Statistical Program for windows (paper I) and SPSS 15.0 Statistical Program for windows (papers II, III, IV and V). The statistical program MLwin 2.0. was used for the multilevel analysis in papers III and V.

The level of significance for all analysis was set at 0.05.

Table 1 describes the different statistical methods applied in the different papers.

Table 1 – Statistical Methods applied in the different papers.

	Paper I	Paper II	Paper III	Paper IV	Paper V
Two-sided Student's T-test with Bonferroni adjustments	x	x	x	x	x
Chi-square test and Somer's d	x				
Chi-square test	x			x	x
Spearman's correlation				x	
Multinomial Logistic Regression	x	x		x	
Categorical Principal Components Analysis (CATPCA)				x	
ANCOVA			x		
Multilevel Linear Regression			x		x

4.Papers

Paper I

Santos, R.; Aires, L.; Santos, P.; Ribeiro, J. C. & Mota, J. **Prevalence of overweight and obesity in a Portuguese sample of adults: results from the Azorean Physical Activity and Health Study.** ***Am J Hum Biol 2008*****;20(1):78-85.**

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Original Research Article

Prevalence of Overweight and Obesity in a Portuguese Sample of Adults: Results from the Azorean Physical Activity and Health Study

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ABSTRACT The sample of this study comprised 9,991 adults who participated in the Azorean Physical Activity and Health Study, Portugal. Body mass index was calculated from self-reported weight and height and used as a depended variable. Physical activity was assessed by the International Physical Activity Questionnaire—short version, participants were classified in three categories according to their METs min/week values: low physical activity level, moderate physical activity level, and health-enhancing physical activity. Smoking status, alcohol consumption, and socio-economic status were also collected. Results showed that the prevalence of overweight and obesity was 33.5 and 18.8% in women, and 45.8 and 16% in men, respectively. The prevalence of health-enhancing physical activity individuals was 23.6% for women and 43.8% for men. Logistic regression analysis showed that age was a predictor of overweight and obesity, in both genders. Smoking status was negatively associated with overweight and obesity, in both genders. Men with low physical activity level and higher sitting time (≥3 h/day) were more likely to be obese. Low socio-economic status and alcohol consumption were found to be predictors for overweight and obesity for women. In summary, the prevalence of overweight and obesity among Azorean adults is high. Targeted programs aimed to lower the prevalence of overweight and obesity, among the Azoreans, should focus on elderly, on women with low socio-economic status, and on men aged 26–40 years, due to the higher prevalence of overweight and obesity and low levels of physical activity observed in these groups. Am. J. Hum. Biol. 20:78–85, 2008.

Overweight and obesity are a growing problem worldwide and have reached epidemic proportions in western countries (James et al., 2001) including Portugal (do Carmo et al., 2006; Marques-Vidal and Dias, 2005).

Although some studies suggest that genetics may explain some cases of the observed obesity (Bouchard, 1996), age, gender, ethnicity, socio-economic status (SES), and other features of lifestyle and environment such as diet, smoking status, alcohol consumption, and lack of physical activity (PA) are more likely to explain the recent epidemic of obesity (Swinburn and Egger, 2002).

Obesity and physical inactivity are important risk factors for coronary heart disease, hypertension, dyslipidemia, Type 2 diabetes, and certain types of cancer (Fang et al., 2003; Fransson et al., 2003; Lee et al., 2001; Meyer et al., 2002) and have a direct relation to premature mortality (Erlichman et al., 2002; Katzmarzyk et al., 2003; Paffenbarger et al., 1986) and health related quality of life (Allison et al., 1999; Brown et al., 2003; Fine et al., 1999; Hassan et al., 2003).

In Portugal, the latest estimates indicate that, in each year, 39% of deaths in adults are due to cardiovascular diseases (CVD) (INE, 2002). This prevalence is among the highest in Europe (WHO, 2002) and it has increased significantly, from 26.4% in 1960 to 38.7% in 2000 (INE, 2002). The Portuguese prevalence of overweight and obesity is high, but it has increased only slightly in the past decade (Marques-Vidal and Dias, 2005) in contrast with other countries (Gutierrez-Fisac et al., 2000; Martinez et al., 2004; Ogden et al., 2006; Rennie and Jebb, 2005). Regarding leisure time PA, several studies have indicated that Portugal has one of the lowest PA prevalence in Europe (Martinez-Gonzalez et al., 2001; van der Wilk and Jansen, 2005; Varo et al., 2003). However, one study reported that the prevalence of "sufficient total PA" in Portugal was comparable with the mean prevalence of the European countries (Sjöström et al., 2006). Smoking has declined in the past 20 years in the majority of the countries of the European Union, but not in Portugal. Moreover, in Portugal like in almost European Union countries, total alcohol consumption levels have been falling (van der Wilk and Jansen, 2005). Despite this, to the best of our knowledge no studies have been carried out in Azores Islands (a Portuguese archipelago), and no data are known about those factors. Thus, the aims of this study were (i) to determine and compare the obesity status and (ii) to explore social and behavioral factors associated with obesity in Azorean adults.

METHODS

Study design and sampling

Data for the present study is derived from the Azorean Physical Activity and Health Study (APAHS); a cross-sectional study carried out by the Azorean Government with the collaboration of our Research Centre. The APAHS main objective is to examine PA patterns, obesity status, environmental correlates of PA and obesity, and other lifestyles characteristics of the Azoreans, to design and imple-

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ment interventions aimed to increase PA levels in the adult population.

The Azorean Archipelago, Portugal, in the North Atlantic, comprises nine islands with a population of 240,024 people (INE, 2003). The Azorean Archipelago is one of the seven "outermost regions" of the European Union. Those regions are distinguished by their "low population density, their considerable distance from mainland Europe, and for their considerable structural backwardness," and therefore received extra funding from the European Union to improve living conditions (EU, 1997).

Data were collected in the spring 2004. This study was conducted according to the guidelines of the Helsinki Declaration of Human Studies. Data collection was accomplished by mailing questionnaires to the adult residents. The questionnaires were sent through school children to their parents or relatives aged 18 or older. The potential sample included 16,000 adults (≥18 years old) from 7,500 households. Participants received an information letter asking them to participate in this survey. A response rate of 87.6% (14,017 questionnaires) was obtained.

Individuals who did not meet the age criterion (18–65 years) were excluded, as well as those whose questionnaires contained a majority of missing information or were repeated (n = 3,985). Pregnant women were also deleted from the analysis (n = 41). Therefore, the sample of this study included 9,991 adults (99.5% Caucasians) (5,723 women and 4,268 men) aged 37.78 ± 9.45 years.

Measures

The questionnaire included several demographic, social, and behavioral variables, such as marital status, ethnicity, SES, PA behavior, perceived environmental attributes, alcohol consumption, smoking habits, and anthropometric measures.

Anthropometric measures. Body mass index (BMI) was calculated from self-report weight and height and used to evaluate weight status according to WHO recommendations. BMI was divided in three categories: normal weight (18.5 kg/m^2 ≥ BMI < 25 kg/m^2); overweight (25 kg/m^2 ≥ BMI < 30 kg/m^2); and obese (BMI ≥ 30 kg/m^2) (WHO, 2000).

Physical activity. PA was assessed using the short "last week" version of the international physical activity questionnaire (IPAQ). IPAQ reports separately vigorous-intensity PA, moderate-intensity PA, and walking in terms of frequency and duration of each specific type of activity, in the past 7 days. This instrument also reports the time spent sitting in an ordinary week day. Both categorical and continuous indicators of PA are possible from the IPAQ short version. Validity and reliability data from 12 countries (including Portugal) showed that IPAQ has comparable validity and reliability to CSA monitor and to other self-report measures of PA (Craig et al., 2003). Cleaning data and out-of-range values, as well as data analysis were done in accordance with the International Consensus Group on PA Measures.

According to the guidelines for data processing and analysis of the IPAQ (IPAQ, 2005), total PA was expressed as MET-min/week (metabolic equivalent), by weighting the reported minutes per week, in each activity category, by the metabolic equivalent specific to each activity (Total PA = 3.3 METs × walking minutes × walking days + 4.0 METs × moderate-intensity activity minutes × moderate days + 8.0 METs × vigorous-intensity activity minutes × vigorous-intensity days). Subjects were then classified in three categories according to their level of PA:

i. Category 1—is the lowest level of PA, individuals who did not meet criteria for categories two or three are considered to have a "low PA level".
ii. Category 2—the minimum pattern of activity to be classified as "moderate PA level" meets any one of the following three criteria: (a) 3 or more days of vigorous activity for at least 20 min/day; (b) 5 or more days of moderate-intensity activity or walking for at least 30 min/day; and (c) 5 or more days of any combination of walking, moderate-intensity, or vigorous intensity activities achieving a minimum of at least 600 MET-min/week.
iii. Category 3—HEPA active (health-enhancing physical activity)—is a more active category, computed for people who exceed the minimum public health PA recommendations. The IPAQ scientific group proposes this new cut point, which equates to at least ~1 h of total activity per day, of at least moderate-intensity activity. The minimum pattern of activity to be classified as "HEPA Active" meets any one of the following two criteria: (a) vigorous-intensity activity on at least 3 days achieving a minimum of at least 1,500 MET-min/week; (b) 5 or more days of any combination of walking, moderate-intensity, or vigorous-intensity activities achieving a minimum of at least 3,000 MET-min/week.

Inactivity. The time spend sitting in an ordinary week day was also accessed using the short "last week" version of the IPAQ and it was considered a proxy measure of inactivity (Hagströmer et al., 2006; Sjöström et al., 2006). Participants were divided in two categories according to the median value: Group 1 (<3 h/day) and Group 2 (≥3 h/day) (IPAQ, 2005).

Socio-economic status. Education level, personal income per month, and occupation were collected.

Education level was collapsed into four groups in accordance to the Portuguese educational system: Group 1 (4 years' education—sub secondary level); Group 2 (4–9 years' education); Group 3 (10–12 years' education—secondary level); and Group 4 (higher education).

Subjects were categorized in six groups according to their personal income per month: Group 1 (<500 euros); Group 2 (500–875 euros); Group 3 (875–1,250 euros); Group 4 (1,250–1,625 euros); Group 5 (1,625–2,000 euros); and Group 6 (≫2,000 euros).

Occupation was labeled according to the Portuguese National Institute of Statistics (INE, 1994). For the purpose of this study a six-point scale was recoded for occupation (occupational score), according to the mean PA level of each occupation group—from manual workers (lower values) to executive workers (higher values).

The SES index variable was obtained by multiplying the education level (ranging from 1 to 4) of each individual with their personal income per month (ranging from 1 to

TABLE 1. Descriptive characteristics of the participants according to gender

	Women (n – 5,723)	Men (n – 4,268)	
			t test value[a]
Age (years) (mean + SD)	36.8 + 9.1	39.2 + 9.8	−12.543*
BMI (kg/m^2) (mean + SD)	26.0 + 4.6	26.4 + 3.8	−3.890*
PA (METs-min/week) (mean + SD)	2,066.40 + 2,151.40	3,248.63 + 2,641.30	−23.917*
Sitting (min/day) (mean + SD)	235.70 + 159.91	250.23 + 171.96	−4.304*
SES (mean + SD)	29.9 + 31.6	23.3 + 33.5	5.406*
BMI (number (%))			χ^2 value
Normal weight	2,730 (47.7%)	1,630 (38.2%)	277.523*
Overweight	1,917 (33.5%)	1,955 (45.8%)	0.373
Obesity	1,076 (18.8%)	683 (16.0%)	87.805*
PA (number (%))			
Low PA level	2,375 (41.5%)	1,259 (29.5%)	342.723*
Moderate PA level	1,998 (34.9%)	1,141 (26.7%)	233.975*
HEPA active	1,350 (23.6%)	1,868 (43.8%)	83.382*
Sitting (number (%))			
<3 h/day	3,038 (53.1%)	2,149 (50.4%)	152.366*
≥3 h/day	2,685 (46.9%)	2,119 (49.6%)	66.685*
Smoking (number (%))			
Nonsmokers	4,217 (73.7%)	1,574 (36.9%)	1,206.260*
Former smokers	445 (7.8%)	880 (20.6%)	142.811*
Current smokers	1,061 (18.5%)	1,814 (42.5%)	197.221*
Alcohol consumption (number (%))			
Nondrinkers	3,546 (62.0%)	1,257 (29.5%)	1,090.885*
Occasional drinkers	2,022 (35.3%)	2,121 (49.7%)	2.366
Regular drinkers	155 (2.7%)	890 (20.9%)	516.962*

[a]Compares means between genders using t test statistics with Bonferroni adjustments.
*$P < 0.001$.

6) and occupation score (ranging from 1 to 6). The SES index (education level × personal income per month × occupation score) ranged from 1 to 144 was divided into tertiles (first tertile: <9; second tertile: 10–20; third tertile ≫21). Similar procedure described elsewhere (Manios et al., 2005).

Smoking. Participants were classified as nonsmokers, former smokers (individuals who had stopped smoking for at least 6 months), occasional smokers (individuals who smoked less than one cigarette a day), and current smokers (individuals who smoked at least one cigarette a day) (WHO, 1997). Occasional smokers were recoded and combined with current smokers due to their small sample size.

Alcohol consumption. Participants were classified as nondrinkers (no alcohol for more than 12 months), former-drinkers (no alcohol for more than 6 months), occasional drinkers (individuals who drank less than 1 U/week), regular drinkers (individuals who drank 1–10 U/week), and heavy drinkers (individuals who drank more than 10 U/week) (DepHealth, 2004). Former-drinkers were recoded and combined with nondrinkers; heavy drinkers were recoded and combined with regular drinkers, due to their small samples sizes.

Statistical analyses

All analyses were conducted separately for men and women.

Two-sided Student's t test with Bonferroni adjustments was used to compare gender differences in continuous variables (mean values). χ^2 test was used to compare gender differences.

Cross-tabulation examined unadjusted bivariate associations with χ^2 test and Somer's d was used to indicate the strength and direction of the relationship between BMI categories and the other variables.

A multivariate logistic regression model was fitted to assess odds ratio (OR) (i.e. the effect size or the likelihood) and 95% confidence intervals (CI) for overweight and obesity. The variables independently associated with BMI (age, SES, PA, sitting time, smoking status, and alcohol consumption) were considered candidates for the multivariate model.

All statistical analysis were performed using SPSS 14.0 Statistical Program for windows. The level of significance for all analyses was set at 0.05.

RESULTS

The sample distribution by gender and age was similar to the general population (INE, 2003). The general sample features are shown in Table 1.

Men had significantly higher mean values for age, BMI, PA MET, and time spent sitting, than women ($P < 0.001$). SES was, on average, significantly lower in men ($P < 0.001$). The prevalence of overweight and obesity was 33.5 and 18.8% in women, and 45.8 and 16% in men, respectively ($P < 0.001$ for obesity). About 34.9% of women had a moderate PA level and 23.6% achieved the HEPA active category; corresponding figures for men were 26.7 and

TABLE 2. Prevalence of overweight and obesity in men and women, according to age, socio-economic status, physical activity, sitting time, smoking, and alcohol consumption

	Women (n – 5,723)					Men (n – 4,268)				
	Normal weight	Overweight	Obese	χ^2 value	Somer's d value	Normal weight	Overweight	Obese	χ^2 value	Somer's d value
Age				385.649*	0.232*				237.720*	0.175*
18–25 years	73.7	19.2	7.1			66.9	28.0	5.0		
26–40 years	49.8	33.8	16.4			36.7	49.0	14.3		
41–65 years	34.3	38.3	27.4			32.1	47.7	20.2		
SES				183.550*	−0.156*				7.957	0.020
Low	37.9	37.6	24.5			38.8	45.2	16.0		
Middle	44.7	33.9	21.3			40.9	44.1	14.9		
High	59.5	29.9	10.6			35.2	48.0	16.8		
Physical activity				1.059	−0.07				21.922*	−0.162*
Low PA level	47.3	33.7	18.9			34.3	47.6	18.1		
Moderate PA level	47.9	32.9	19.2			36.5	47.0	16.5		
HEPA active	48.1	33.9	18.0			41.8	43.9	14.3		
Sitting				39.433*	−0.088*				14.861*	0.063*
< 3h/day	43.9	35.2	20.9			40.8	44.8	14.5		
≥ 3h/day	52.0	31.6	16.5			35.6	46.9	17.6		
Smoking				171.422*	−0.193*				83.756*	−0.085*
Nonsmokers	43.0	35.5	21.5			34.9	48.6	16.5		
Former smokers	53.5	31.0	15.5			29.5	48.9	21.6		
Current smokers	64.0	26.6	9.4			45.2	41.9	12.9		
Alcohol consumption				48.649*	−0.72*				5.747	0.030
Nondrinkers	45.1	34.1	20.8			40.3	44.9	14.8		
Occasional drinkers	53.0	31.6	15.4			37.8	46.3	16.0		
Regular drinkers	36.8	44.5	18.7			36.2	46.1	17.8		

*$P < 0.001$.

43.8% ($P < 0.001$). Men were more frequently smokers (42.5% vs. 18.5%) ($P < 0.001$) and regular drinkers (20.9% vs. 2.7%) ($P < 0.001$).

Table 2 depicts the prevalence of overweight and obesity in men and women by age, SES, PA, sitting time, smoking status, and alcohol consumption. Older men and women were more frequently to be overweight and obese than young adults ($P < 0.001$). Women with low SES had significantly higher prevalence of overweight and obesity compared with those in the middle and higher SES group ($P < 0.001$). Such statistical significance was not found in men. Prevalence of overweight and obesity was lower among men in HEPA active category ($P < 0.001$) compared with those in the low and moderate PA categories. This statistical significance was not found in women. Current smokers men and women had a lower prevalence of overweight and obesity compared with nonsmokers and former smokers ($P < 0.001$). In women, regular drinkers had lower prevalence of normal weight compared with nondrinkers or occasional drinkers ($P < 0.001$). Such statistical significance was not found in men. As it can be observed in Table 2, all the significant associations found between BMI categories and the other variables are weak (Somer's d value <0.5). Significant positive associations were found between BMI categories and age (for both genders) and between BMI categories and sitting (only in men). Significant negative associations were found between BMI categories and PA (only in men) and between BMI categories and SES and alcohol consumption (only for women). Smoking was negatively associated with BMI, in both genders.

Logistic regression analysis (Table 3) showed that the OR for overweight and obesity increased steeply as age increased in both genders. In women, SES was significantly linked with BMI, with women in the high SES having smaller odds for overweight and obesity. In men, the lack of PA and sitting for more than 3 h/day appeared to be statistically significant predictors of obesity. Current smokers presented a smaller tendency to be overweight or obese in both genders. Alcohol consumption was found to be a predictor for overweight in women.

DISCUSSION

To our knowledge this is the first study addressing the prevalence of overweight and obesity and other health related factors in the Azorean Archipelago using a large sample. Other studies have been conducted in Portugal, but only with residents living in the mainland (do Carmo et al., 2006; Marques-Vidal and Dias, 2005).

Data in the present study indicate that the prevalence of overweight and obesity was 33.9 and 18.7% in women, and 45.9 and 16% in men, respectively. Overall, among Azorean adults 56.4% had a BMI ≥ 25 kg/m^2. Comparing with other studies, that also used self-report data, the prevalence of overweight and obesity among Azoreans is higher than the average values described in European Union countries (overweight—25.6% in women and 36.6% in men; obesity—10.1% in women and 9% in men) (Martinez et al., 1999) and higher than those reported for the Portuguese population. In Portugal, Marques-Vidal and Dias (2005) showed that 32.3% of women were overweight and 14.2% obese and that 42.5% of men were overweight and 11.5% obese.

As in Spain (Martinez et al., 2004), the prevalence of overweight and obesity among islanders is higher than in the mainland, suggesting that some unique cultural and environmental features may influence this prevalence, such as social and cultural background, values, beliefs, and life expectations. This discrepancy may reflect different regional levels of socioeconomic development, since societies in the process of modernization tend to have increases in the prevalence of obesity (WHO, 2000).

TABLE 3. Adjusted odds ratios (OR) and 95% confidence intervals (CI) from logistic regression model predicting overweight and obesity

	Women (n = 5723)				Men (n = 4268)			
	Overweight		Obesity		Overweight		Obesity	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Age								
18–25 years[a]	1		1		1		1	
26–40 years	2.853**	(2.303 – 3.535)	4.082**	(2.967 – 5.617)	3.263**	(2.592 – 4.107)	5.206**	(3.367 – 8.050)
41–65 years	4.603**	(3.663 – 5.784)	9.574**	(6.902 – 13.281)	3.500**	(2.779 – 4.406)	7.832**	(5.092 – 12.045)
SES								
Low[a]	1		1		1		1	
Middle	0.871	(0.742 – 1.023)	0.856	(0.712 – 1.029)	1.033	(0.858 – 1.243)	0.807	(0.639 – 1.020)
High	0.523*	(0.436 – 0.626)	0.287**	(0.288 – 0.363)	0.927	(0.779 – 1.103)	0.994	(0.770 – 1.283)
Physical Activity								
Low PA level[a]	1		1		1		1	
Moderate PA level	0.981	(0.853 – 1.128)	0.995	(0.839 – 1.180)	0.977	(0.814 – 1.173)	0.903	(0.709 – 1.151)
HEPA active	1.022	(0.872 – 1.196)	0.947	(0.779 – 1.152)	0.851	(0.719 – 1.007)	0.758*	(0.604 – 0.951)
Sitting								
<3 h/day[a]	1		1		1		1	
≥3 h/day	1.018	(0.894 – 1.160)	1.082	(0.922 – 1.269)	1.164*	(1.005 – 1.347)	1.350*	(1.106 – 1.649)
Smoking								
Non Smokers[a]	1		1		1		1	
Former Smokers	0.815	(0.648 – 1.026)	0.819	(0.610 – 1.100)	0.993	(0.816 – 1.209)	1.171	(0.914 – 1.501)
Current Smokers	0.560**	(0.475 – 0.659)	0.383**	(0.302 – 0.485)	0.614**	(0.526 – 0.716)	0.537**	(0.432 – 0.667)
Alcohol Consumption								
Non Drinkers[a]	1		1		1		1	
Occasional Drinkers	1.005	(0.880 – 1.149)	1.272	(0.789 – 2.053)	1.124	(0.958 – 1.320)	1.197	(0.958 – 1.494)
Regular Drinlers	1.704*	(1.175 – 2.470)	0.938	(0.793 – 1.109)	1.080	(0.886 – 1.317)	1.216	(0.932 – 1.587)

[a]Reference category.
*$P < 0.05$.
**$P < 0.001$.

Similar to what some authors suggest to explain the Western–Eastern differences in overweight and obesity in Europe, the Azorean may experience a process of modernization reflected by a transition in the social, economic environments, nutrition, and PA patterns by a delay effect of the Western lifestyle (Martinez et al., 1999).

Regarding gender differences, the higher prevalence subjects with a BMI $\gg$ 25 kg/m^2 found in men compared with women is consistent with other studies in the USA and in Europe (IOTF, 2006; Martinez et al., 1999; Ogden et al., 2006).

In agreement with other investigations older men and women were more frequently overweight and obese (Ogden et al., 2006; Rennie and Jebb, 2005; Rodriguez Artalejo et al., 2002; Zhang and Wang, 2004) and tend to have lower levels of PA (data not shown) than young adults (Sjöström et al., 2006). Decreased PA and decreased energy expenditure with ageing predispose to fat accumulation and fat redistribution. Reduction in muscle mass (sarcopenic obesity) is an important determinant of physical function and metabolic rate (Beaufrere and Morio, 2000; Villareal et al., 2004), suggesting the need of tailored obesity reduction and PA promotion strategies in this group. Regarding age, it is worthy to comment that only 36.7% of men aged 26–40 years have a normal BMI. This group of men is too young to have such a high prevalence of overweight and obesity. Typically, in the developed countries, adults tend to gain weight between the third and the sixth decade, after this period weight is often maintained, followed by a modest decrease in the ninth decade (Rolland-Cachera et al., 1991), which means that these men may continue to gain weight for the next two or three decades, if their lifestyles remain unchanged. This segment of the population should be considered at risk and assigned for selective lifestyles interventions.

An inverse association of smoking habits and overweight/obesity was found as in previous studies (Akbartabartoori et al., 2005; Rodriguez Artalejo et al., 2002; Tur et al., 2005). However, the health benefits of smoking cessation exceed the risk associated to any small rise in BMI that may follow giving up smoking (Akbartabartoori et al., 2005), since smoking is associated with a variety of diseases, including CVD and cancer (USDHHS, 2004). In addition, overweight nonsmokers have a longer life expectancy than thin smokers (Davis et al., 1994; Peeters et al., 2003) and smokers tend to cluster other risk behaviors like low leisure time PA, high alcohol consumption, and low fruit/vegetable intake (Chiolero et al., 2006).

Consistent with prior work in Portugal (Marques-Vidal and Dias, 2005), and in other developed countries (Ball et al., 2003; Everson et al., 2002; Gutierrez-Fisac et al., 2000; Laaksonen et al., 2005; Manios et al., 2005; Martinez et al., 1999; Sundquist and Johansson, 1998; Zhang and Wang, 2004) we found an inverse association between socioeconomic position and BMI, in women but not in men. Some investigators have suggested that individuals of low social class report less leisure time PA and are less likely to consume healthy or low-fat diets (Baghurst et al., 1990; Crespo et al., 1999; Jeffery and French 1996; Smith and Owen, 1992). Education is positively associated with more health-related knowledge (Tur et al., 2005) and a higher capacity to put it into practice (Ball and Crawford, 2006). On the other hand, individuals with low incomes have less access to healthy food (usually more expensive) and are less able to pay for exercise classes or to buy sport equipment (Ball and Crawford, 2006). In addition, women are also more likely to perceive themselves as overweight, more concerned about their body weight and image, and are more aware of their weight status (Tur et al., 2005). Dieting and weight control efforts are more common among women in the high strata (Jeffery and French, 1996). Those may be possible explanations for this gender difference in the association between SES and obesity.

In our study, the compliance with HEPA report, suggests that the prevalence of active individuals was 32.2% (23.6% for women and 43.8% for men). These findings are comparable with the average prevalence across European Union countries (29%) and with the Portuguese prevalence (33.1%) (Sjöström et al., 2006). The prevalence of HEPA active individuals in our study is higher among those with low SES ($P < 0.001$) (data not shown), but because we used the short version of the IPAQ (and therefore we calculated total PA) it is not possible to distinguish whether these high levels of PA are mostly from PA in leisure time or work related. We can only speculate that these high levels of PA in the low SES are more likely to be work related since 35.9% of our samples were manual workers (data not shown). Therefore, the higher prevalence of overweight and obesity, among the low SES participants, is probably more related to alcohol consumption and other risk factors that we did not access, like dietary habits and environment characteristics, rather than the lack of PA. Nevertheless, as mentioned in other studies (Chen and Mao, 2006; King et al., 2001; Martinez-Gonzalez et al., 1999; Rodriguez Artalejo et al., 2002; Tur et al., 2005) men in the HEPA active category had smaller OR for obesity and those with higher sitting time had higher OR for overweight and obesity, supporting the idea that regular PA may decrease the risk of overweight and obesity (USDHHS, 1996).

Some limitations should be noted. First, our data relies on self-reported variables, which means that respondents, particularly those in the higher SES (Droomers et al., 1998), may have over-report behaviors considered to be positive, like PA and under-report the negative ones, like weight, alcohol consumption, and smoking status. BMI based on self-report data, could indicate an underestimation of the true prevalence of overweight and obesity (Yun et al., 2006). Nevertheless, BMI from self-report data was found to be sufficiently accurate and widely used in epidemiological studies, once objectively measurements of weight and height in large samples can be difficult and unaffordable. PA accessed by self-report data is not as precise as more objective methods such as accelerometers, but questionnaires have acceptable validity and reliability for population studies, particularly when the intention is to differentiate those with "high" vs. "low" PA levels (Katzmarzyk et al., 2003). However, PA prevalence in this study can be somewhat overestimated. Second, dietary habits were not assessed. Third, our study did not collect any information on the duration of obesity and PA habits. Also, this is a crosssectional study and therefore the direction of the association between overweight and obesity and the other variables can not be assumed. Despite the limitations, our results suggest that promoting healthy lifestyles may contribute to lower the prevalence of overweigh and obesity.

In conclusion, the prevalence of overweight and obesity among Azorean adults is high. Advanced age was a predictor of overweight and obesity and smoking status was neg-

atively associated with BMI, in both genders. An inverse association between SES and obesity and between alcohol consumption and overweight was found in women, but not in men. Men with low PA levels and higher sitting time were more likely to be obese.

Considering the results of this study, targeted programs for Azoreans aimed to lower the prevalence of overweight and obesity, should focus on elderly; on women with low SES, and on men aged 26–40 years due to the higher prevalence of overweight and obesity and low levels of PA observed in these groups along with more universal interventions as way to reach everyone at the same time. Nevertheless, longitudinal studies are required to monitor, study trends over time, and analyze the population subgroups that are most affected by obesity and other health related outcomes.

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Paper II

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Physical Activity and Other Lifestyle Behaviors in a Portuguese Sample of Adults: Results from the Azorean Physical Activity and Health Study

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Abstract

Background: The aims of this study were: to describe physical activity (PA) prevalence and compare it with other countries; to investigate possible associations between PA and other lifestyle behaviors, in Azorean adults.

Methods: 9991 adults (5723 women), aged 37.8±9.5 years, of the 2004 Azorean Physical Activity and Health Study. IPAQ assessed PA. All other lifestyle behaviors (age, gender, education level, income, employment, marital status, number of children, meal frequency, sleep time, sitting time, body mass index and alcohol and tobacco consumptions) were also self-reported.

Results: 57.1% of the participants met current PA recommendations and 32.2% were categorized as Health Enhancing PA (HEPA). Women were less likely to achieve PA recommendations, as well as the HEPA level. In both genders, higher education level, employment status, higher income and sitting for more than 3h/day were negative predictors of HEPA; and, having at least 5 meals/day was positive predictor for the same PA level.

Conclusions: There is a significant proportion of Azoreans, particularly women, that does not do enough PA. Targeted programs for Azoreans aimed to increase PA levels should pay especial attention on women, and consider a multi-factorial approach, once several lifestyle behaviors seem to interact with PA levels, in this population.

Keywords: Physical Activity; Lifestyle Behaviors; IPAQ

Introduction

The lack of physical activity (PA) is an important risk factor for coronary heart disease, hypertension, dyslipidemia, obesity, type 2 diabetes, certain types of cancer, osteoporosis, arthritis, anxiety and depression [1-7], and has a direct relation to premature mortality [8-10] and health related quality of life [11-14]. Physical inactivity is also associated with an increase use of hospital services [15]. Therefore, physical inactivity is recognized as a major public health concern. Since the 70's, several international organizations have developed PA guidelines for healthy adults. These guidelines have changed significantly in the past years and, since 2007, the ACSM/AHA PA guidelines recommend the accumulation of 30 minutes or more of moderate-intensity aerobic PA on five days per week or 20 minutes of vigorous-intensity aerobic PA on three days per week [16].

Despite the benefits of regular PA on health, the prevalence of the population that comply with the recommended levels of PA is undesirable in many developed countries [17, 18]. Thus, a better understanding of the prevalence and correlates of PA in populations is particular important to design and implement programs to promote physical activity.

In Azores, a Portuguese archipelago, previous data from the Azorean Physical Activity and Health Study (APAHS) has shown that 32.2% of the adult population (23.6% for women and 43.8 % for men) achieve the HEPA Level (Health-Enhancing Physical Activity)[19], but, to the best of our knowledge, little is known about the factors associated with PA, in this population. Thus, the purposes of this study were (i) to describe PA prevalence and compare it with other countries; and (ii) to investigate possible associations between PA and other lifestyle behaviors, in Azorean adults. We hypothesizes that PA prevalence in this sample is comparable with other European Countries; and that the lifestyle behaviors associated with PA differ between genders.

Methods

Data for the present study are derived from the Azorean Physical Activity and Health Study (APAHS). The main objective of the APAHS was to examine PA patterns, obesity status, environmental correlates of PA and obesity and other lifestyles characteristics of the Azoreans, in order to design and implement interventions to increase PA levels in the adult population.

Study design, sampling and measures are reported elsewhere [19, 20]. Briefly, data were collected in the spring of 2004 by mailing questionnaires to the adult residents of all the Azorean Islands – a Portuguese Archipelago. The questionnaires were sent through school children to their parents or relatives aged 18 or older. A response rate of 87.6% (14 017 questionnaires) was obtained. For the present study, 9 991 adults (5 723 women and 4 268 men), aged 37.8±9.5 years old, for whom questionnaires contained complete information on PA and anthropometric data, were included in the analysis.

BMI [weight(kg)/height(m)^2] was calculated from self-reported weight and height. Participants were divided in three categories: normal weight; overweight and obese [21].

PA was assessed using the short version of the International Physical Activity Questionnaire [22]. Validity and reliability data from 12 countries (including Portugal) showed that IPAQ has comparable validity and reliability to CSA monitor and to other self-reported measures of PA [23].

According to the Guidelines for data Processing and Analysis of the IPAQ [22], total PA was expressed as metabolic equivalent (MET).minutes/week, by weighting the reported minutes per week, in each activity category, by the metabolic equivalent specific to each activity (Total PA = 3.3 MET x walking minutes x walking days + 4.0 MET x moderate-intensity activity minutes x moderate days + 8.0 MET x vigorous-intensity activity minutes x vigorous-intensity days). Subjects were then classified in three categories according to their level of PA in MET-minutes/week:

(i) Category 1 - is the lowest level of PA, individuals who did not meet criteria for categories two or three are considered to have a “low PA level”;

(ii) Category 2 - the minimum pattern of activity to be classified as "moderate PA level" meets any one of the following three criteria: a) three or more days of vigorous activity of at least 20 minutes per day; b) Five or more days of moderate-intensity activity or walking of at least 30 minutes per day; c) Five or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 600 MET-minutes/week.

(iii) Category 3 – HEPA level (Health-Enhancing Physical Activity) - is a more active category, computed for people who exceed the minimum public health physical activity recommendations. The IPAQ scientific group proposes this new cut point, which equates to approximately at least one hour of total activity per day, of at least moderate-intensity activity. The minimum pattern of activity to be classified as "HEPA level" meets any one of the following two criteria: a) vigorous-intensity activity on at least three days achieving a minimum of at least 1500 MET-minutes/week; b) Five or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum of at least 3000 MET-minutes/week.

Total PA was also expressed as minutes per week, by summing the time spent in moderate PA and vigorous PA, to determine the proportion of the sample that meets the ACSM/AHA PA guidelines [16]. Subjects were classified in three categories according to their level of PA in min/week: inactive (participants who reported no PA/week); insufficiently active (participants that reported less than 150 min/week of at least moderate-intensity PA or less than 20 min/week of vigorous-intensity PA) and sufficiently active (participants that reported 150 min/week or more of at least moderate-intensity PA or 20 min/week or more of vigorous-intensity).

The time spend sitting in an ordinary week day was also assessed using the short version of the IPAQ and it was considered a proxy measure of inactivity [24, 25] Participants were divided in two categories according to the median value: group 1 (< 3 hours/day) and group 2 (≥ 3 hours/day) [22].

Other variables included in this analysis were defined as follows:

(i) Education level - group 1 (4 years' education - sub secondary level); group 2 (4-9 years' education); group 3 (10-12 years' education - secondary level) and group 4 (higher education).

(ii) Income per month - group 1 (< 500 euros); group 2 (500 - 875 euros); group 3 (>875 euros).

(iii) Occupation - Student; Employed and Retired /Unemployed.

(iv) Smoking - Non smokers, former smokers (individuals who had stopped smoking for at least six months), occasional smokers (individuals who smoked less than one cigarette a day) and current smokers (individuals who smoked at least one cigarette a day) [26]. Occasional smokers were recoded and combined with current smokers due to their small sample size.

(v) Alcohol Consumption - Non drinkers (no alcohol for more than twelve months), former-drinkers (no alcohol for more than six months), occasional drinkers (individuals who drank less than one unit per week), regular drinkers (individuals who drank one to 10 units per week) and heavy drinkers (individuals who drank more than 10 units per week) [27]. Former-drinkers were recoded and combined with non drinkers; heavy drinkers were recoded and combined with regular drinkers, due to their small samples sizes.

(vi) Sleep Duration - Based on participants' sleeping hours per day, individuals were classified in three groups: group 1 (< 7hours/day); group 2 (7-8 hours/day); group 3 (> 8hours/day) [28].

(vii) Marital Status - single/never married; married/partner and separate/divorced/widowed.

(viii) Number of Children per person - none; one child; two children and three or more children.

(ix) Meal Frequency - Daily Meal Frequency was assessed by the question: How many meals per day do you consume? The main meals represented meals that were conventionally served on a plate [29]. For statistical analysis the participants were grouped into three meal frequency categories: three or fewer; four and five or more.

Statistical Analysis

Two-Tailed Student's T-test with Bonferroni adjustments was used to compare gender differences in continuous variables (mean values for age, BMI and PA).

Multinomial Logistic Regression was used to obtain adjusted odds ratio (OR) and 95% confidence intervals (CI) to analyze the influence other variables on PA levels. Logistic Regression models were constructed separately for men and women. In each model all variables were tested simultaneous.

All statistical analysis were performed using SPSS 15.0 Statistical Program for windows (SPSS, Inc. Chicago). The level of significance for all analyses was set at 0.05.

Results

Sixty eight percent of the participants had 9 or less years of education, 92.5% were employed, 28.9% were current smokers, 10.9% drank regularly, and, 56.4% had a BMI≥25 Kg/m^2. Women were on average younger (p<0.001) and thinner (p<0.001) than men. Women, on average, also reported less sitting time (p<0.001) and, less PA than men in terms of duration (p<0.001) and energy expenditure (p<0.001). The general sample features are shown in table 1.

Table 1 – Participants characteristics.

	Total (n=9 991)			Women (n = 5 723)			Men (n = 4 268)			T-Test [a]
	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD	
Age (years)	18	65	37.8±9.5	18	65	36.8±9.1	18	65	39.15±9.8	-12.543 *
BMI (Kg/m^2)	18.5	57.6	26.2±4.3	18.5	57.6	26±4.6	18.5	51.6	26.4±3.8	-3.890 *
PA (MET.min/week)	0	9576	2571.4±2443.9	0	9576	2066.4±2151.4	0	9576	3248.6±2641.3	-23.917 *
PA (min/week)	0	960	307.4±330.7	0	960	241.6±304.8	0	960	395.5±343.2	-23.236 *
Sitting Time (min/day)	10	840	241.9±165.3	10	840	235.7±159.9	10	840	250.2±171.9	-4.304 *
	n	%		n	%		n	%		Chi-Square
Education Level										
4 years	3028	30.3		1588	27.7		1440	33.7		71.407 *
5-9 years	3780	37.8		2168	37.9		1612	37.8		
10-12 years	2127	21.3		1262	22.1		865	20.3		
Higher education	1056	10.6		705	12.3		351	8.2		
Employment										
Employed	9242	92.5		5302	92.6		3940	92.3		31.435 *
BMI										
Normal	4360	43.6		2730	47.7		1630	38.2		157.140 *
Overweight	3872	38.8		1917	33.5		1955	45.8		
Obese	1759	17.6		1076	18.8		683	16.0		

PA – Physical Activity
BMI – Body Mass Index
[a] Compares means between genders using T-test statistics with Bonferroni adjustments.
* p<0.001

Table 2 illustrates the prevalence of PA and sitting time for the total sample and by gender. More than half of all the participants (57.1%) met current PA recommendations, 32.2% were categorized as HEPA level and 48.1% spent

at least 3 h/day sitting. More women than men showed No PA/week (p<0.001), No vigorous PA/week (p<0.001) and Low PA level (p<0.001). Men had higher prevalence of sitting for more than 3h/day (p<0.001).

Table 2 – Prevalence of Physical Activity and Sitting time for the total sample and by gender.

	Total	Women	Men	X^2 Test
	% (95%CI)	% (95%CI)	% (95%CI)	
Low PA level	36.4 (35.7-37.1)	41.5 (40.4-42.6)	29.5 (30.4-28.6)	342.723*
Moderate PA level	31.4 (30.8-32)	34.9 (34-35.8)	26.7 (25.9-27.5)	233.975*
HEPA Level	32.2 (31.6-32.8)	23.6 (23-24.2)	43.8 (42.5-45.1)	83.382*
Inactive (No PA/week)	32.5 (31.8-33.1)	39.1 (38.9-40.9)	22.1 (21.7-23.1)	546.272*
Insufficient PA	10.5 (10.3-10.67)	11.7 (11.4-12.0)	8.8 (8. 6-9.1)	82.635*
Sufficient PA[a]	57.5 (55.1-58.2)	48.3 (47.1-49.6)	68.8 (66.7-70.8)	5.068**
Sitting time ≥3h/day	48.1 (47.2-49)	46.9 (45.7 - 48.1)	49.6 (48.1 - 51.1)	66.695*

PA – Physical Activity
HEPA – Health-Enhancing PA
[a] – Sufficient PA = ≥150 min/week of moderate to vigorous PA or ≥ 20 min/week of vigorous PA.
* p<0.001
** p<0.05

In women, logistic regression analysis (Table 3) demonstrated that a marital status other than single reduced significantly the odds of reaching both moderate PA (by 40.8 to 49%; p<0.05) and HEPA levels (by 54.5 to 55.1%; p<0.01). Education level and monthly income were also negatively associated with PA; women with 10-12 school years or higher education were 47.1 and 46.1% (p<0.001) less likely to have a HEPA level, respectively; whereas women with a monthly income greater than 500 euros had fewer odds of attain the highest PA category by 17.5 to 28.8% (p<0.05). Sitting for 3h/day or more was a significant negative predictor for both moderate PA (OR=0.783; p<0.001) and HEPA (OR=0.628; p<0.001) levels. In contrast, being a student or unemployed/retired increased the odds of having a moderate PA level (by 2.296 fold p<0.001) and a HEPA level (by 2.275 fold p<0.001), respectively. Having five or more meals/day improved the odds of achieving the moderate PA and HEPA categories, by 33.6 and 53.2% (p<0.001), respectively. Women with two children were 28% (p<0.05) more likely to accomplish moderate PA level. Likewise, drinking occasionally as a positive predictor for both Moderate PA (OR=1.169; p<0.05) and HEPA levels (OR=1.223; p<0.001).

Table 3 –Prevalence and Odds Ratios and 95% Confidence Intervals from Multinomial Logistic Regression model predicting Moderate Physical Activity Level and HEPA, in women.

Women	Low PA Level [a]		Moderate PA Level				HEPA Level			
	n	%	n	%	OR	95% CI	n	%	OR	95% CI
Age										
18-32 years [a]	595	36.3	581	35.4	1		465	28.3	1	
33-38 years	730	45.1	514	31.8	0.944	0.783-1.238	373	23.1	0.908	0.739-1.116
39-42 years	490	43.3	416	36.7	1.177	0.959-1.443	226	20	0.835	0.660-1.057
43-65 years	560	42	487	36.5	1.209	0.983-1.486	286	21.5	0.844	0.667-1.068
Education Level										
4 years [a]	632	39.8	536	33.8	1		420	26.4	1	
5-9 years	858	39.6	755	34.8	1.065	0.901-1.259	555	25.6	0.859	0.715-1.032
10-12 years	530	42	480	38	0.971	0.784-1.202	252	20	0.529*	0.411-0.680
Higher education	355	50.4	227	32.2	0.774	0.577-1.037	123	17.4	0.539*	0.378-0.768
Income per month										
< 500 € [a]	669	38	603	34.2	1		490	27.8	1	
500 – 875 €	1182	40.5	1044	35.7	0.942	0.814-1.089	696	23.8	0.825†	0.703-0.968
> 875 €	524	50.4	351	33.8	0.887	0.694-1.133	164	15.8	0.712†	0.526-0.963
Employment										
Employed [a]	2267	42.8	1820	34.3	1		1215	22.9	1	
Student	54	19.4	131	47	2.296*	1.534-3.437	94	33.6	1.204	0.780-1.859
Unemployed/Retired	54	38	47	33.1	0.947	0.627-1.430	41	28.9	2.275*	1.477-3.503
Marital Status [b]										
Single/Never Married [a]	169	25.3	276	41.3	1		224	33.4	1	
Married/Partner	2013	43.8	1555	33.9	0.510*	0.373-0.697	1024	22.3	0.455*	0.327-0.634
Separate/Divorced/Widowed	181	41.3	161	36.8	0.592†	0.410-0.856	96	21.9	0.449*	0.300-0.672
Number of Children [c]										
None [a]	319	31.7	372	37	1		315	31.3	1	
1	534	43.4	426	34.7	1.181	0.915-1.523	269	21.9	0.864	0.656-1.138
2	973	42.7	822	36.1	1.280†	0.999-1.639	482	21.2	0.904	0.693-1.179
≥ 3	517	45.6	355	31.3	0.958	0.735-1.250	261	23	0.831	0.625-1.105
Meal Frequency										
≤ 3/day [a]	910	42.4	496	33.8	1		510	23.8	1	
4/day	971	43.6	778	35	1.010	0.877-1.164	476	21.4	0.934	0.794-1.099
≥ 5/day	494	36.5	724	36.6	1.336*	1.129-1.582	364	26.9	1.532*	1.270-1.848
Sleep time										
< 7 hours/day	242	41.5	204	35	1		137	23.5	1	
7-8 hours/day	1749	42.2	1431	34.6	0.951	0.775-1.168	961	23.2	0.948	0.750-1.198
> 8 hours/day	384	38.4	363	36.3	0.984	0.770-1.157	252	25.3	0.924	0.700-1.220
Smoking										
Non Smoker [a]	1731	41	1487	35.3	1		999	23.7	1	
Ex Smoker	184	41.3	164	36.9	1.033	0.817-1.306	97	21.8	1.020	0.774-1.344
Current Smoker	460	43.4	347	32.7	0.890	0.750-1.054	254	23.9	0.980	0.809-1.188
Alcohol										
Non Drinker [a]	1510	42.6	1221	34.4	1		815	23	1	
Occasional Drinker	806	39.9	727	36	1.169†	1.020-1.340	489	24.1	1.223*	1.046-1.429
Regular Drinker	59	38.1	50	32.3	1.179	0.794-1.749	46	29.6	1.489	0.979-2.260
Sitting Time										
< 3h/day [a]	1158	38.1	1066	35	1		814	26.8	1	
≥ 3h/day	1217	45.3	932	34.7	0.783*	0.686-0.893	536	20	0.628*	0.539-0.731
BMI										
Normal [a]	1124	41.2	957	35.1	1		649	23.8	1	
Overweight	801	41.8	658	34.3	0.984	0.853-1.135	458	23.9	1.015	0.863-1.194
Obese	450	41.8	383	35.6	1.034	0.867-1.232	243	22.6	0.932	0.761-1.140

*p<0.001; †p<0.05; [a] – reference category; [b] – There were 24 women with unknown marital status; [c] - There were 78 women with unknown number of children; PA – Physical Activity; HEPA – Health-Enhancing PA; OR – Odds Ratio; CI – Confidence Intervals.

Regarding men, the results presented in Table 4 showed that age was a negative predictor for PA; men with an age behind 39 years, were less likely to reach the HEPA level, by 28.5% to 29.6%, p<0.05. The same tendency occurred with education level in the two highest education categories (OR=0.576; p<0.001 for 10-12 school years and OR=0.480; p<0.001 for higher education). Men with an income per month between 500 and 875 euros were 18.2% (p<0.05) less likely to accomplish the HEPA level when compared with those earning less than 500 euros/month. Being unemployed or retired was negatively associated with HEPA level (OR=0.488;p<0.05) whereas being a student had the opposite effect (OR=1.852 p<0.05). The odds for achieving HEPA level decreased steeply as the number of children increased, from 32% to 33.9% (p<0.05). Current smoking was also negatively related to moderate PA and HEPA levels (OR=0.817; p<0.05 and OR=750; p<0.05, respectively). Like in women, men with a sitting time of three or more hours a day were less likely to achieve both moderate PA level (24.7%; p<0.05) and HEPA level (55.6%; p<0.001). Having four or five or more meals per day was positively associated with HEPA level (OR=1.232; p<0.05 and OR=1.349; p<0.05, respectively). Among men, regular drinking was the other lifestyle characteristic positively associated with HEPA level (OR=1.429; p<0.05).

Table 4 –Prevalence and Odds Ratios and 95% Confidence Intervals from Multinomial Logistic Regression model predicting Moderate Physical Activity Level and HEPA, in men.

Men	Low PA Level [a]		Moderate PA Level				HEPA Level			
	n	%	n	%	OR	95% CI	n	%	OR	95% CI
Age										
18-32 years [a]	189	21	213	23.7	1		496	55.3	1	
33-38 years	270	31.3	208	24.1	1.038	0.736-1.465	386	44.6	0.819	0.608-1.103
39-42 years	292	32.1	249	27.4	1.111	0.786-1.571	368	40.5	0.704†	0.520-0.954
43-65 years	508	31.8	471	29.5	1.292	0.920-1.814	618	38.7	0.715†	0.530-0.964
Education Level										
4 years [a]	392	27.2	336	23.3	1		712	49.5	1	
5-9 years	447	27.8	410	25.4	1.136	0.908-1.422	755	46.8	0.866	0.709-1.058
10-12 years	282	32.6	287	33.2	1.219	0.921-1.614	296	34.2	0.576*	0.441-0.753
Higher education	138	39.3	108	30.8	0.932	0.649-1.338	105	29.9	0.480*	0.338-0.683
Income per month										
< 500 € [a]	308	24.6	289	23	1		656	52.4	1	
500 – 875 €	480	28.1	453	26.6	0.955	0.769-1.185	773	45.3	0.818†	0.676-0.990
> 875 €	471	36	399	30.5	0.925	0.713-1.201	439	33.5	0.823	0.649-1.044
Employment										
Employed [a]	1171	29.7	1032	26.2	1		1737	44.1	1	
Student	23	15.2	44	29.1	1.535	0.830-1.598	84	55.7	1.852†	1.052-3.260
Unemployed/Retired	65	36.7	65	36.7	1.092	0.747-1.598	47	26.6	0.488*	0.324-0.733

Marital Status [b]										
Single/Never Married [a]	96	17.5	141	25.7	1		311	56.8	1	
Married/Partner	1124	31.4	960	26.8	0.798	0.491-1.296	1495	41.8	0.826	0.538-1.268
Separate/Divorced/Widowed	24	21.4	34	30.4	1.217	0.620-2.389	54	48.2	1.161	0.626-2.156
Number of Children [c]										
None [a]	157	19.8	206	26	1		429	54.2	1	
1	272	32.8	196	23.6	0.690	0.520-1.139	362	43.6	0.675†	0.477-0.955
2	543	31.2	501	28.8	0.887	0.614-1.283	696	40	0.680†	0.486-0.951
≥ 3	267	31.7	225	26.7	0.770	0.520-1.016	350	41.6	0.661†	0.463-0.944
Meal Frequency										
≤ 3/day [a]	783	31.4	663	26.6	1		1050	42	1	
4/day	341	27.1	338	26.9	1.204	0.919-1.577	579	46	1.232†	1.035-1.467
≥ 5/day	135	26.3	140	27.2	1.204	0.939-1.369	239	46.5	1.349†	1.050-1.733
Sleep time										
< 7 hours/day	159	28.2	172	30.5	1		233	41.3	1	
7-8 hours/day	926	30.1	806	26.2	0.797	0.627-1.014	1347	43.7	0.933	0.741-1.176
> 8 hours/day	174	27.8	163	26.1	0.790	0.575-1.084	288	46.1	0.847	0.630-1.140
Smoking										
Non Smoker [a]	424	26.9	424	26.9	1		726	46.2	1	
Ex Smoker	279	31.7	243	27.6	0.864	0.688-1.085	358	40.7	0.853	0.689-1.056
Current Smoker	556	30.7	474	26.1	0.817†	0.674-0.992	784	43.2	0.750†	0.628-0.896
Alcohol										
Non Drinker [a]	380	30.2	319	25.4	1		558	44.4	1	
Occasional Drinker	634	29.9	598	28.2	1.205	0.989-1.469	889	41.9	1.147	0.956-1.376
Regular Drinker	245	27.5	224	25.2	1.220	0.950-1.572	421	47.3	1.429†	1.138-1.794
Sitting Time										
< 3h/day [a]	484	22.5	505	23.5	1		1160	54	1	
≥ 3h/day	775	36.6	636	30	0.753†	0.630-0.900	708	33.4	0.444*	0.377-0.523
BMI										
Normal [a]	432	26.5	417	25.6	1		781	47.9	1	
Overweight	599	30.6	536	27.4	0.991	0.822-1.195	820	42	0.870	0.733-1.033
Obesity	228	33.4	188	27.5	0.956	0.745-1.226	267	39.1	0.800	0.635-1.009

*p<0.001; †p<0.05; [a] – reference category; [b] – There were 28 men with unknown marital status; [c] - There were 64 men with unknown number of children; PA – Physical Activity; HEPA – Health-Enhancing PA; OR – Odds Ratio; CI – Confidence Intervals.

Discussion

This study provides, for the first time, a general idea of the PA prevalence and related lifestyle behaviors in a large sample of Azorean adults.

Several studies from different countries have documented PA levels of the adult population; however, comparison between studies is somewhat difficult, given the variety of methods used to measure PA and the PA domain assessed. Due to feasibility and economic costs, most of the epidemiological studies have used questionnaires however; the use of different questionnaires makes comparisons difficult. On the other hand, leisure-time PA has been one of the most frequently assessed domains of PA, but, current PA guidelines for adults emphasize total PA, not only leisure time PA. The IPAQ was developed

to overcome these limitations, i.e.: a standardized questionnaire, translated into different languages, which covers all the PA domains and therefore allows comparisons between studies and populations.

In the APAHS, the short version of the IPAQ was chosen to measure PA levels not only due to feasibility concerns, but also to be possible to compare the Azorean PA levels with other populations. Therefore, the discussion of our results, in light of other studies, is confined to investigations that also assessed PA with IPAQ; exceptions are referred throughout the text.

In 2006, data from the Eurobarometer Study showed that only one-third of the adult European population achieved the HEPA category; and data from Portugal showed similar results [25]. Al-Hazzaa et al (2006) reported that 25.1% of the Saudis adults met the HEPA level [30]. Kavouras et al (2007) demonstrated that only 15.4% of the Greeks living in the Attica region were categorized in the HEPA level [31]. Duncan et al (2006) showed that 32% of the Hong Kong Chinese were in the HEPA category [32]. Bergman et al. (2008) reported that 26% of the Sweden's reached the highest PA category [33]. More recently a WHO 51 country survey showed that, worldwide 15.2% of men and 19.8 % of women exhibits low physical activity levels, and that, within the European region, Turkey (29% for men and 43.5% for women) and Spain (27.5% for men and 32.9 for women) showed the highest prevalence of low PA levels [34]. Apparently, the Azoreans are not that different from the rest of the Europeans (that participated in the Eurobarometer study), since our results show that 32.2% of the participants reached the HEPA category. However, the differences observed between genders among the Azoreans (23.6% in women and 43.8% in men) are more pronounced when compared with the Portuguese participants of the Eurobarometer Study (29.8% in women and 36.9% in men) [25].

Considering the new 2007 ACSM/AHA PA guidelines, the prevalence of active participants is 57.1% (48.3% for women and 68.8% for men, $p<0.001$).Our findings also showed that 40% of women reported No PA/week. Studies that assess only leisure time PA under-represent peoples' PA. This may be of importance, particularly in developing societies like Azores, were occupation PA and housework PA may typify a substantial proportion of men's

and women's total PA, respectively. In fact, data from our study reveled 12.9% of women do not a have work outside home and 51.2% of men are manual workers (data not shown). In an Irish study, with the Institute of Public Health PA questionnaire, Livingstone et al (2001) showed that men can be twice as active in occupational and leisure time activities, while women are three times more active in household pursuits [35]. Therefore, considered that IPAQ measures all PA domains, the prevalence of Azorean women with No PA/week is somewhat worrying, and should be taken into account when designing PA promotion programs for this population.

Regarding sitting time, it is noteworthy to point out that in this study the median value for this behavior was 3h/day, whereas in other studies such as the Eurobarometer Study [25], the EUPASS study [36] and the IPS-Sweden study [24], median values found for this behavior were considerable higher, 6h/day, 4.8h/day and 5h/day, respectively.

Taking into consideration that the Azorean Archipelago is one of the outermost regions of the European Union and that about 70% of the participants in this study had no more than 9 years of education, the negative associations found between income per month and education level with HEPA level, as well as, the prevalence of HEPA level and sitting time observed, we can speculate that PA levels in this population are mostly work-related and that leisure time PA in may not be a frequent behavior. But the use of the short version of the IPAQ does not let us verify this supposition. In fact, IPAQ short version measures all PA domains but it does not differentiate them. Future studies in the Azorean population could consider using IPAQ long version in order to confirm or to rule out this hypothesis. Since some studies (that did not used IPAQ to measure PA) have shown that low socio-economic position is a negative predictor for leisure time PA [37, 38], and others revealed that Portugal has one of the lowest leisure time PA prevalence in Europe [39-41]. Similarly, Bergman at al (2008), with the IPAQ - IPS-Sweden study, also showed that subjects in the highly PA category were less likely to have a college/university degree [33]. Nevertheless, no significant relations were found between education level and PA in the Eurobarometer study [25].

The negative association between age and PA, in men, is not surprising, and confirms previous research [42, 43]. The fact that men achieved the highest PA categories more frequently than women is also not new, and it has been widely reported, regardless of the method used to measure PA or the domain of PA assessed [17, 18, 24, 35, 39, 44, 45].

Literature has produced mixed results about the association between marital status and PA [45]. In Azorean women, being married/living with a partner was a negative predictor for moderate PA and HEPA levels, whereas in men this association was not found, which disagrees with a previous study [46]. Some authors hypothesize that time pressures of juggling career and family responsibilities have a great impact on women and reduces significantly their leisure-time [47]. Nevertheless, having 2 children has positively associated with moderate PA level, in women.

Contrary to other investigations [48], in this study no significant relations were found between BMI status and PA levels. Even so, taken together, the high prevalence of overweight/obesity and the relatively low prevalence of HEPA level in this population are troubling. And we can hypothesize that if these numbers became trends they can point out to an imminent epidemic of chronic disease that may place an enormous public health burden [49]. Moreover, 38.5 % of the participants in this study combines a BMI$\geq$ 25 Kg/m^2 with the lack of sufficient physical activity (i.e. do not achieve the HEPA level), that is to say, that according to the American Heart Association [50], have at least two risk factors for a variety of chronic diseases (data not shown).

In this context, it is also important to notice the positive association found between PA and meal frequency. In both genders, having 5 or more meals/day was associated with HEPA level. Despite the fact that regular PA and healthful diets are among the most important health predictors, the relation between these two behaviors is scarce [51]. Although it is not consensual and current guidelines on nutrition do not refer to the desirable number of meal per day [52, 53], it might be possible that the most active participants tend to distribute their caloric intake in several small amounts.

Study Limitations

In this study the use of questionnaires may have biased our results. The use of self-reported variables might have resulted in an overestimation of behaviors considered to be positive, like PA and in an underestimation the negative ones, like body mass, alcohol consumption and smoking status. The short form of the IPAQ was chosen to measure PA levels in this population, but future studies might consider the use of the long form of this questionnaire, in order to better understand PA patterns by PA domain (i.e. work related PA, transportation PA, housework PA and leisure time PA).

The generalization of the results of this study, to the adult Azorean population, is limited due to the nature of our sampling design, which was not a random sampling strategy.

Due to the cross-sectional nature of this survey the direction of the association between PA and other health behaviors, can not be presumed.

Conclusions

Regardless of clear evidence that regular PA has positive effects on people's health, there is a significant proportion of Azoreans, particularly women, that does not do enough PA to attain these health benefits.

Despite the limitations of our study, our results suggest that targeted programs for Azoreans aimed to increase PA levels should pay especial attention on women, and consider a multi-factorial approach, as several lifestyle behaviors seem to interact with PA levels, in this population. Nevertheless, regular surveillance is required in order to monitor, study trends over time and analyze the population subgroups that are most affected by the lack of PA. Future studies may also offer guidance for PA promotion programs.

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Paper III

Santos, R.; Pratt, M.; Ribeiro, J.C.; Santos, P. M.; Carvalho, J. & Mota, J. **Walking and Body Mass Index in a Portuguese Sample of Adults: Results from the Azorean Physical Activity and Health Study.** ***(submitted)***

Walking and Body Mass Index in a Portuguese Sample of Adults: A Multilevel Analysis.

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Running Title: Walking and Body Mass Index in Portuguese Adults.

Disclaimer: The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Abstract

Overweight and obesity have reached epidemic proportions in Portugal. The purpose of this study was to investigate the cross-sectional associations between walking and body mass index (BMI). This study comprised 9991 adults (5723 women), aged 37.8±9.5 years old, from the 2004 Azorean Physical Activity and Health Study. Walking was assessed with the International Physical Activity Questionnaire, and expressed as min/week. BMI was calculated from self-reported weight and height. A series of multilevel linear regressions models were fitted to assess regression coefficients and standard error predicting BMI. Results show that in both genders and after adjustments for potential cofounders, walking was not a significant predictor of BMI. Therefore, our analysis does not extend the findings of previous studies as it demonstrates no significant associations between walking and BMI, after adjustments for potential cofounders. Nevertheless, among Azoreans walking should be encouraged, as walking has other health benefits, beyond controlling obesity.

Key- Words: Walking, Physical Activity; Obesity.

Introduction

The consequences of obesity include physical, psychological and social aspects, which impact quality of life. Although genetics is a strong component of obesity, lifestyle and environmental changes typical of industrialized societies are more likely to explain the recent obesity epidemic.

Walking is regarded as one of the most popular leisure time PA pursuits in Europe (Vaz de Almeida et al 1999). Literature has shown that walking may decrease the risk of diabetes, improve lipid profile and cognitive function, have a favourable effect on body fat and body mass gain and, reduce cardiovascular risk (Hamer and Chida 2008). Additionally, “brisk” walking appears to meet the minimum intensity recommended to achieve cardio respiratory benefits in unfit populations (ACSM 1998). Despite the importance of these issues for public health prevention strategies, no data exists regarding the Azorean population. Therefore, the purpose of this study was to investigate the cross-sectional associations between walking and body mass index (BMI) among Azoreans.

Methods

Data for the present study are derived from the Azorean Physical Activity and Health Study. The study methods are reported elsewhere (Santos et al 2008). Briefly, data were collected in 2004 by mailing questionnaires to the adult residents of all the Azorean Islands – a Portuguese Archipelago. For this study, 9991 adults, aged 37.8±9.5 years old, for whom questionnaires contained complete information on the variables of interest.

BMI was calculated from self-reported weight and height.

Walking, PA and sitting time were assessed with the International Physical Activity Questionnaire - short version. Walking and PA were expressed as minutes per week. PA was computed by multiplying the reported minutes of moderate and vigorous PA (excluding walking) by the number of PA days. Walking was computed by multiplying the reported minutes per week of walking by the number of walking days. Sitting time was expressed as minutes by day.

Other variables included in this analysis were:

(i) Education level; participants were divided in four groups: 4 years' education; 5-9 years' education; 10-12 years' education and higher education.

(ii) Smoking: Non smokers, former smokers, occasional smokers and current smokers.

(iii) Alcohol Consumption: Non drinkers, former-drinkers, occasional drinkers, regular drinkers and heavy drinkers.

(iv) Sleep Duration: Number of sleeping hours per day.

(v) Meal Frequency: Daily Meal Frequency was assessed by the question: How many meals per day do you consume? The main meals represented meals that were conventionally served on a plate.

ANCOVA was used to analyze differences in BMI between walking groups (participants were divided in tertiles). Covariates were age, educational level, sitting time and PA.

To analyze the relation between BMI and walking, a series of Multilevel Linear Regression models were fitted to assess regression coefficients (β) and standard errors (SE) predicting BMI. Subjects were nested in 3 levels: level 1 – subject; level 2 – municipality; level 3 – island. The final (best) models included walking, age, education level, total PA, sitting time, sleep duration, tobacco and alcohol consumptions and, meal frequency. The women' final model also included a random intercept for municipality. The men' final model also included random intercepts for island and municipality; a random slope (island) for age and, a random slope (municipality) for sleep duration.

Statistics were performed using SPSS15.0 and MLWin2.0 ($p<0.05$).

Results

ANCOVA showed no significant differences in BMI across walking tertiles, (F=1.262; *p*>0.05, for women; F=0.429; *p*>0.05, for men). Table 1.

Table 1– Mean Body Mass Index by Walking Group.

	Women (n = 5723)			**Men (n = 4268)**		
	Walking 1st Tertil (0-44 min/week) n=1878	Walking 2nd Tertil (45-210 min/week) n=2114	Walking 3rd Tertil (≥211 min/week) n=1731	Walking 1st Tertil (0-33 min/week) n=1551	Walking 2nd Tertil (34-210 min/week) n=1356	Walking 3rd Tertil (≥211 min/week) n=1361
Body Mass Index (kg/m^2) Mean ± SD	25.9 ± 0.12	25.98 ± 0.1	26.17 ± 0.11	26.5 ± 0.09	26.34 ± 0.11	26.22 ± 0.09

ANCOVA – Covariates: age, sitting time, total physical activity (excluding walking) and education level.
F=1.262; *p*>0.05, for women. F=0.429; *p*>0.05, for men.

Walking was not a significant predictor for BMI, after adjusting for cofounders, in both genders. Table 2.

Table 2 – Multilevel linear Regressions predicting BMI.

		Model 1 β (SE)	Model 2[a] β (SE)
Women	Walking min/week	0.000027 (0.000314) [n.s.]	0.000119 (0.001939) [n.s.]
Men	Walking min/week	-0.000665 (0.000228)*	-0.000321 (0.000226)[n.s.]

β - Regression Coefficient; SE – Standard Error
* - p<0.05 (based on the Wald test)
n.s. - non significant (based on the Wald test)
[a] - Model 2 – Adjusted for age, education level, total PA (excluding walking), sitting time, sleeping time, meal frequency, and alcohol and tobacco consumptions.

Discussion

Our data did not show statistically significant differences in mean BMI between walking groups, and walking was not a significant predictor for BMI, in either gender. Whereas some studies (Murphy et al 2007, Thompson et al 2004) have described negative relationships between BMI and walking, others pointed-out that the negative association between PA and BMI is restricted to vigorous rather than moderate-intensity activities (Bernstein et al 2004). While, moderate PA may be adequate to decrease cardiovascular risk factors and mortality, it may not be sufficient for weight control (Bernstein et al 2004). Guo et al (1999) also demonstrated that higher PA levels were required to preserve fat free mass and reduce body fat with aging. Although the cross sectional nature of this study does not allow casual relationships to be determined, our data suggests that walking per se may not increase energy expenditure sufficiently to prevent high BMI, after adjustments for cofounders. Nevertheless, obese individuals may benefit more from their walking time than normal weight participants and therefore walking should be encouraged. For instance, Hills et al (2006) demonstrated that in spite of walking slower, obese individuals had a more intense physiological response than normal-weight counterparts even if they “walked for pleasure”, which equated with an exercise intensity sufficient to improve cardio respiratory fitness in obese, but not in normal-weight individuals. Browning and Kram (2005) also showed that walking was 11% more calorically expensive for obese women compared to normal-weight, when done at similar speeds, which may imply a greater cardiovascular effort for the obese. In our study we did not assess the intensity of walking, which may be an important

feature that differentiate walking patterns in normal weight and overweight/obese individuals. Nonetheless, based on previous research, it is possible that our overweight/obese subjects may have had grater cardiovascular benefits from walking than normal weight subjects, for the same walking time and intensity.

From a public health perspective, strategies to promote PA among the Azorean adults should encourage walking behaviour, due to it health benefits (Hamer and Chida 2008). Walking is a safe, accessible and virtually cost free form of PA. Walking, as any other form of moderate PA, can be more readily adopted and maintained though out the lifetime than vigorous PA. Walking as a way to commute provides a feasible method of integrating PA into modern lifestyles.

In conclusion, our analysis does not extend the findings of previous studies as it demonstrates no significant associations between walking and BMI, after adjustments for cofounders. Although the cross sectional nature of this study does not allow casual relationships to be determined, our data suggests that walking per se may not increase energy expenditure sufficiently to prevent high BMI, after adjustments for cofounders. Nevertheless, among Azoreans walking should be encouraged, as levels are relatively low and, walking has other health benefits, beyond controlling obesity.

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Paper IV

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Physical activity and perceived environmental attributes in a sample of Portuguese adults: Results from the Azorean Physical Activity and Health Study

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ABSTRACT

Objectives. The aim of the present study was to determine whether the relation of perceived neighbourhood attributes to reported Physical Activity (PA) levels in Azorean adults varied by gender and body mass index (BMI).

Methods. 7330 adult participants (4104 women), aged 38.1 ± 9.3 years, from the 2004 Azorean Physical Activity and Health Study. They answered the Environmental Module and the short version of the International Physical Activity Questionnaire (IPAQ). Height and weight were self-reported.

Results. After adjustments for age, BMI, education level and island of residence, the dimension Infrastructures, Access to destinations, Social environment and Aesthetics was positively associated with moderate PA level and Health-Enhancing Physical Activity (HEPA) level, only in women. When participants were categorized by BMI status, the same dimension was a significant predictor for moderate PA level in normal weight men and women, and for HEPA level only in overweight/obese women, after controlling for age, education level and island of residence.

Conclusions. The dimension Infrastructures, Access to destinations, Social environment and Aesthetics was predictors of higher PA levels in Azorean adults. Targeted programs for Azoreans to increase PA levels should consider that this set of environmental features seem to act synergistically and are positively associated with PA.

Introduction

In adults, the lack of Physical Activity (PA) is recognized as a major health concern in most industrialized countries, due to its contribution to a multiplicity of negative health outcomes (Erlichman et al., 2002; Fang et al., 2003; Fransson et al., 2003; Katzmarzyk et al., 2003; Lee et al., 2001; USDHHS, 1996).

From an ecologic point of view, PA behaviour can be seen as a result of an interaction between personal attributes and environmental factors (Bandura, 1986). Research in this field has focused on availability and proximity of facilities for exercise and recreation (Humpel et al., 2002), physical features of the environment, neighbourhood safety, aesthetics and social organization of communities (Poortinga, 2006). Several cross-sectional studies have identified positive relations between total PA and perceived (Duncan et al., 2005) or objectively measured (Humpel et al., 2002) activity-friendly environmental characteristics. Conversely, a number of studies have found negative relations between PA and people's body weight (Chen and Mao, 2006; King et al., 2001; Martinez-Gonzalez et al., 1999), raising the question that certain aspects of the environment may promote or discourage PA and energy expenditure and therefore have an indirect influence on people's body weight (Poortinga, 2006). Gender is also known to be significantly associated with PA; men typically exhibit higher PA levels than women (USDHHS, 1996). However it is not clear if environmental attributes influence people's PA levels differently according to their gender and Body Mass Index (BMI) status.

The need to increase PA levels in a population basis is considered a public health priority. Therefore, to design and implement relevant policies and effective programs, it is essential to identify which set of environmental features provides potential opportunities for PA, since changes in the environment affect a large number of people on a relatively permanent basis.

The Azorean Archipelago — Portugal, in the North Atlantic, comprises nine islands with a population of 240024 people (INE, 2003). The Azores is one of the seven "outermost regions" of the European Union (EU, 1997) and has some unique geographical features and urban design that differ from the mainland. All of the islands have volcanic origins, numerous landscapes with virgin forest and green fields. Most of the urban areas are small and located in the coast. Tourism, fishing and agriculture are the most important occupations.

In this context, the aim of this study was to determine whether perceived neighbourhood attributes were associated with reported PA levels in Azorean adults, by gender and BMI categories.

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Table 1
Dimension loadings based on principal components analysis for categorical data for the environmental module of the International Physical Activity Prevalence Study Questionnaire

	Dimension	Questions	Loadings	Cronbach's Alpha	Eigen value	% of variance
1	Infrastructures, access to destinations, social environment and aesthetics	There are sidewalks on most of the streets in my neighbourhood.	0.606	0.749	3.393	19.70%
		The sidewalks in my neighbourhood are well maintained and not obstructed.	0.545			
		There are facilities to bicycle in or near my neighbourhood.	0.708			
		Places for bicycling in and around my neighbourhood are well maintained and not obstructed.	0.673			
		My neighbourhood has several free or low cost recreation facilities.	0.725			
		Many shops, stores, markets are within easy walking distance of my home.	0.477			
		There are many places to go within easy walking distance of my home.	0.493			
		I see many people being physically active in my neighbourhood.	0.605			
		There are many interesting things to look at wile walking in my neighbourhood.	0.514			
2	Neighbourhood safety	The crime rate in my neighbourhood makes it unsafe to go on walks at night.	0.692	0.628	2.444	14.19%
		The crime rate in my neighbourhood makes it unsafe to go on walks during the day.	0.630			
		There are many four-way intersections in my neighbourhood.	0.408			
		There is so much traffic on the streets that it makes it difficult or unpleasant to walk.	0.766			
		There is so much traffic on the streets that it makes it difficult or unpleasant to ride a bike.	0.743			
3	Residential density	What is the main type of housing in your neighbourhood?	0.402	0.376	1.548	8.99%
4	Transit stop	It is within a 10–15 min walk to a transit stop (bus, train, trolley) from my home.	0.417	0.130	1.139	6.61%
5	Household motor vehicles	How many motor vehicles in working order are there in your household?	0.887	0.023	1.022	5.93%
					Total	55.42%

Data from Azorean Physical Activity and Health Study — Portugal (data collected in 2004).

Table 2
Participants' characteristics

	Women (n=4104)	Men (n=3226)	T-test value[a]
	Mean (SD)	Mean (SD)	
Age (years)	37.12 (8.94)	39.42 (9.57)	−10.533**
BMI (kg/m^2)	26.35 (4.37)	26.53 (3.59)	−1.924
PA (METs-min/week)	2049.04 (2124.63)	3241.04 (2614.75)	−1.924**
	Number (%)	Number (%)	χ^2 value[b]
BMI			
Normal weight	1839 (44.8)	1174 (36.4)	146.772**
Overweight	1473 (35.9)	1533 (47.5)	1.198
Obese	792 (19.3)	519 (16.1)	56.849**
PA			
Low PA level	1699 (41.4)	933 (28.9)	222.932**
Moderate PA level	1454 (35.4)	890 (27.6)	135.706**
HEPA level	951 (23.2)	1403 (43.5)	86.790**
Education			
<4 years	1074 (26.2)	982 (30.4)	4.117*
5–9 years	1499 (36.5)	1199 (37.2)	33.358**
10–12 years	979 (23.9)	742 (23.0)	32.637**
College/university	552 (13.5)	303 (9.4)	72.516**

Data from Azorean Physical Activity and Health Study — Portugal (data collected in 2004).
[a] Compares means between genders using T-test statistics with Bonferroni adjustments.
[b] Compares prevalences between genders. * $p<0.05$; ** $p<0.001$.
SD — Standard Deviation; BMI — Body Mass Index: Normal weight = 18.5 kg/m^2 ≥ BMI <25 kg/m^2; Overweight = 25 kg/m^2 ≥ BMI <30 kg/m^2; Obese = BMI ≥ 30 kg/m^2. PA — Physical Activity.
Low PA level = individuals who did not meet criteria for Moderate PA level and for HEPA level.
Moderate PA level = any one of the following 3 criteria: a) 3 or more days of vigorous activity of at least 20 min per day; b) 5 or more days of moderate-intensity activity or walking of at least 30 min per day; c) 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving at least 600 MET-min/week.
HEPA level — (Health-Enhancing Physical Activity) = any one of the following 3 criteria: a) vigorous-intensity activity on at least 3 days achieving at least 1500 MET-min/week; b) 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving at least 3000 MET-min/week.

Methods

Study design and sampling

Data for the present study were derived from the Azorean Physical Activity and Health Study. Study design, sampling and measures are reported elsewhere (Santos et al., 2008). Briefly, data collection was accomplished by mailing questionnaires to the adult residents of all islands. The questionnaires were sent through school children to their parents or relatives aged 18 or older.

For the present study, 7330 adults, aged 38.13±9.3 years old, for whom questionnaires contained complete information on PA, environmental variables and anthropometric data, were included in the analysis.

Measures

Anthropometric measures

BMI [weight (kg)/height (m)^2] was calculated from self-reported weight and height. Participants were divided in three categories: normal weight; overweight and obese (WHO, 2000).

Physical activity

PA was assessed using the short version of the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003). Total PA was expressed as metabolic equivalent (MET).min/week, by weighting the reported min/week, in each activity category, by the metabolic equivalent specific to each activity (IPAQ, 2005). Subjects were classified in three categories: Low PA level — individuals who did not meet criteria for the other 2 categories; Moderate PA level — the minimum pattern of activity is any one of the following three criteria: a) ≥3 days of vigorous activity for ≥20 min/day; b) ≥5 days of moderate-intensity activity or walking for ≥30 min/day; c) ≥5 days of any combination of walking, moderate-intensity or vigorous intensity activities achieving ≥600 MET-min/week; HEPA level (Health-Enhancing PA) — computed for people who exceed the minimum public health PA recommendations, which equates to approximately at least one h of PA/day, of at least moderate-intensity activity. The minimum pattern is any one of the following two criteria: a) vigorous-intensity activity on at least three days achieving ≥1500 MET-min/week; b) ≥5 days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving ≥3000 MET-min/week.

Education level

Education level was collapsed into four groups in accordance to the Portuguese Educational System: 4 years' education; 4–9 years' education; 10–12 years' education and higher education.

Perceived environmental attributes

To assess perceived neighbourhood environments we administrated the Environmental Module of the International Physical Activity Prevalence Study questionnaire (IPS, 2002).

Table 3
Odds ratios and 95% confidence intervals from multinomial logistic regression model predicting moderate physical activity level and HEPA level

		Low PA level[a]	Moderate PA level			HEPA level		
		N (%)	*N* (%)	Adjusted[b] OR (95% CI)		*N* (%)	Adjusted[b] OR (95% CI)	
Women								
Infrastructures, access to destinations, social environment and aesthetics	Negative overall perception[a]	892 (44.8)	660 (33.2)	1		437 (22.0)	1	
	Positive overall perception	807 (38.2)	794 (37.5)	1.325	(1.150–1.528)**	514 (24.3)	1.319	(1.121–1.551)**
Men								
Infrastructures, access to destinations, social environment and aesthetics	Negative overall perception[a]	467 (28.2)	481 (29.0)	1		709 (42.8)	1	
	Positive overall perception	466 (29.7)	409 (26.1)	1.149	(0.954–1.384)	694 (44.2)	1.039	(0.876–1.233)
Women								
Neighbourhood safety	Positive overall perception[a]	799 (41.6)	676 (35.2)	1		447 (23.3)	1	
	Negative overall perception	900 (41.2)	778 (35.7)	1.032	(0.891–1.195)	504 (23.1)	1.016	(0.859–1.201)
Men								
Neighbourhood safety	Positive overall perception[a]	425 (29.9)	382 (26.8)	1		616 (43.3)	1	
	Negative overall perception	508 (28.2)	508 (28.2)	1.087	(0.896–1.318)	787 (43.6)	0.999	(0.837–1.192)

Data from Azorean Physical Activity and Health Study — Portugal (data collected in 2004).
[a] - Reference category; [b] - Adjusted for age, Body Mass Index, education level and island of residence * $p<0.05$; ** $p<0.001$.
OR — Odds Ratio; SE — Standard Error; CI — Confidence Intervals; PA — Physical Activity.
Moderate PA level = any one of the following 3 criteria: a) 3 or more days of vigorous activity of at least 20 min per day; b) 5 or more days of moderate-intensity activity or walking of at least 30 min per day; c) 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving at least 600 MET-min/week.
HEPA level — (Health-Enhancing Physical Activity) = any one of the following 3 criteria: a) vigorous-intensity activity on at least 3 days achieving at least 1500 MET-min/week; b) 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving at least 3000 MET-min/week.

The questionnaire has 17 questions about residential density; access to destinations; neighbourhood's infrastructures; aesthetic qualities; social environment; street connectivity; neighbourhood safety and number of household motor vehicles. The question about residential density has 6 response options: detached single-family housing; Townhouses, row houses, apartments or condos of 2–3 stories; Mix of single-family residences and townhouses, row houses, apartments or condos; Apartments or condos of 4–12 stories; Apartments or condos of more than 12 stories; and Don't know/not sure. One question asked about how many motor vehicles there were at the household. The other 15 questions have a four-point Likert response scale: strongly disagree; somewhat disagree; somewhat agree; strongly agree and don't know/doesn't apply response option.

This questionnaire has been used previously and shown good reliability. (Alexander et al., 2006; De Bourdeaudhuij et al., 2003; Mota et al., 2005).

Statistical analyses

Two-sided Student's *T*-test with Bonferroni adjustments was used to compare gender differences in continuous variables (mean values for age, BMI and PA).

Chi-Square was used to compare gender differences in categorical variables (BMI categories, PA categories and education categories).

To explore the relations between PA, BMI and the each environmental variable we performed Spearman's correlations. Most of the activity-friendly environmental variables showed positive significant correlations with PA and negative significant correlations with BMI, in both genders (data not shown). Therefore, in order to reduce the original set of environmental variables into a smaller set of uncorrelated components that represented most of the information found in the original variables,

Table 4
Odds ratios and 95% confidence intervals from multinomial logistic regression model predicting moderate physical activity level and HEPA level by body mass index category, in women

Women		Low PA level[a]	Moderate PA level			HEPA level		
		N (%)	*N* (%)	Adjusted[b] OR (95% CI)		*N* (%)	Adjusted[b] OR (95% CI)	
BMI<25 kg/m²								
Infrastructures, access to destinations, social environment and aesthetics	Negative overall perception[a]	422 (46.1)	289 (31.6)	1		205 (22.4)	1	
	Positive overall perception	351 (38.0)	357 (38.7)	1.445	(1.166–1.791)**	215 (23.3)	1.271	(0.996–1.622)
BMI≥25 kg/m²								
Infrastructures, access to destinations, social environment and aesthetics	Negative overall perception[a]	470 (43.8)	371 (34.6)	1		232 (21.6)	1	
	Positive overall perception	456 (38.3)	437 (36.7)	1.220	(1.007–1.478)*	299 (25.1)	1.345	(1.080–1.675)*
BMI<25 kg/m²								
Neighbourhood safety	Positive overall perception[a]	358 (43.8)	285 (34.8)	1		175 (21.4)	1	
	Negative overall perception	415 (40.6)	361 (35.4)	1.128	(0.903–1.410)	245 (24.0)	1.174	(0.911–1.514)
BMI≥25 kg/m²								
Neighbourhood safety	Positive overall perception[a]	441 (39.9)	391 (35.4)	1		272 (24.6)	1	
	Negative overall perception	485 (41.8)	417 (35.9)	0.948	(0.778–1.155)	259 (22.3)	0.908	(0.725–1.137)

Data from Azorean Physical Activity and Health Study — Portugal (data collected in 2004).
[a] - Reference category; [b] - Adjusted for age, education level and island of residence * $p<0.05$; ** $p<0.001$.
OR — Odds Ratio; SE — Standard Error; CI — Confidence Intervals; PA — Physical Activity.
Moderate PA level = any one of the following 3 criteria: a) 3 or more days of vigorous activity of at least 20 min per day; b) 5 or more days of moderate-intensity activity or walking of at least 30 min per day; c) 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving at least 600 MET-min/week.
HEPA level — (Health-Enhancing Physical Activity) = any one of the following 3 criteria: a) vigorous-intensity activity on at least 3 days achieving at least 1500 MET-min/week; b) 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving at least 3000 MET-min/week.

Table 5
Odds ratios and 95% confidence intervals from multinomial logistic regression model predicting moderate physical activity level and HEPA level by Body Mass Index category, in men

Men		Low PA level[a]	Moderate PA level			HEPA level		
		N (%)	*N* (%)	Adjusted[b] OR (95% CI)		*N* (%)	Adjusted[b] OR (95% CI)	
BMI<25 kg/m²								
Infrastructures, Access to destinations, Social environment and Aesthetics	Negative overall perception[a]	146 (26.1)	125 (22.3)	1		289 (51.6)	1	
	Positive overall perception	145 (23.6)	185 (30.1)	1.514	(1.091–2.101)*	284 (46.3)	1.050	(0.783–1.406)
BMI≥25 kg/m²								
Infrastructures, Access to destinations, Social environment and Aesthetics	Negative overall perception[a]	320 (31.7)	284 (28.1)	1		405 (40.1)	1	
	Positive overall perception	322 (30.9)	296 (28.4)	1.008	(0.802–1.267)	425 (40.7)	1.059	(0.855–1.311)
BMI<25 kg/m²								
Neighbourhood safety	Positive overall perception[a]	188 (35.8)	183 (33.1)	1		351 (63.4)	1	
	Negative overall perception	163 (24.5)	181 (27.2)	1.086	(0.774–1.524)	322 (48.3)	0.924	(0.682–1.252)
BMI≥25 kg/m²								
Neighbourhood safety	Positive overall perception[a]	297 (32.5)	253 (27.7)	1		365 (39.9)	1	
	Negative overall perception	345 (30.3)	327 (28.8)	1.091	(0.861–1.382)	465 (40.9)	1.043	(0.837–1.299)

Data from Azorean Physical Activity and Health Study — Portugal (data collected in 2004).
[a] - Reference category; [b] - Adjusted for age, education level and island of residence * $p<0.05$; ** $p<0.001$.
OR — Odds Ratio; SE — Standard Error; CI — Confidence Intervals; PA — Physical Activity.
Moderate PA level = any one of the following 3 criteria: a) 3 or more days of vigorous activity of at least 20 min per day; b) 5 or more days of moderate-intensity activity or walking of at least 30 min per day; c) 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving at least 600 MET-min/week.
HEPA level — (Health-Enhancing Physical Activity) = any one of the following 3 criteria: a) vigorous-intensity activity on at least 3 days achieving at least 1500 MET-min/week; b) 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving at least 3000 MET-min/week.

and at the same time, to understand the relationships between environmental variables, a Categorical Principal Components Analysis (CATPCA) was conducted. The optimal-scaling approach that is used in CATPCA permits variables to be scaled at different levels. Categorical variables are optimally quantified in the specified dimensionality. As a result, nonlinear relationships between variables can be modelled (Meulman and Heiser, 2005).

In the first CATPCA we explored a solution of 17 dimensions (Meulman and Heiser, 2005). The results showed that only five dimensions satisfied the Keiser criterion of Eigenvalues ≥1 (Meulman and Heiser, 2005), consequently a second CATPCA was conducted with a forced 5-dimensions solution. Component loadings ≥0.4 were considered significant (Meulman and Heiser, 2005). The five dimensions explained 55.42% of the total variance. Only two dimensions (dimension 1: Infrastructures, Access to destinations, Social environment and Aesthetics; and dimension 2: Neighbourhood safety) showed acceptable or good reliability (Cronbach's Alpha > 0.6) (Pestana and Gageiro, 2005) and therefore indexes were constructed only for these dimensions. The index is an arithmetic average of the responses to the questions included in the dimension. The indexes were then recoded and dichotomized on the basis of a median split, dividing the index into negative overall perception and positive overall perception. (Table 1)

Multinomial Logistic Regression was used to obtain adjusted odds ratio (OR) and 95% confidence intervals (CI) to analyse the influence of neighbourhood environmental dimensions on PA levels. The Logistic regression analysis was adjusted for age, BMI, education level and island of residence when participants were divided by gender; and adjusted for age, education level and island of residence when participants were divided by gender and BMI status. The dimensions and the other covariates were tested simultaneously.

Statistical analysis was performed using SPSS 15.0. The level of significance for all analyses was set at 0.05.

Results

The general sample features are shown in Table 2. Men had significantly higher mean values for age and PA (MET), than women ($p<0.001$). The prevalence of overweight and obesity was 35.9 and 19.3% in women, and 47.5 and 16.1% in men, respectively ($p<0.001$ for obesity). Overall 32.1% of the participants were categorized as HEPA level (23.2% of women and 43.5% of men — $p<0.001$).

In Table 3, regression analysis showed that, after adjustments, women with a positive overall perception of the dimension Infrastructures, Access to destinations, Social environment and Aesthetics were 32.5% ($p<0.001$) more likely to have a moderate PA level and 31.9% ($p<0.001$) more likely to have HEPA level. No significant relations were found in men.

As shown in Tables 4 and 5, after adjustments, normal weight women with a positive overall perception of the dimension Infrastructures, Access to destinations, Social environment and Aesthetics were 44.5% ($p<0.001$) more likely to have Moderate PA levels, whereas women with a BMI ≥ 25 kg/m² were 22% ($p<0.05$) more likely to have Moderate PA levels and 34.5% ($p<0.05$) more likely to have HEPA levels. Normal weight men with a positive overall perception of same dimension were 51.4% ($p<0.05$) more likely to have Moderate PA levels.

Discussion

To our knowledge, this is the first study addressing relationships between perceived environmental attributes and PA among Azoreans.

Our results showed that 32.1% of the participants were categorized as HEPA level, which is comparable with previous data for Portugal (Sjöström et al., 2006).

Previous research using self-report measures of environmental attributes, has shown positive associations between total PA and access to facilities for exercise (Booth et al., 2000; Duncan et al., 2005; Sharpe et al., 2004), presence of sidewalks (Duncan et al., 2005; Sharpe et al., 2004) and bike paths (Sharpe et al., 2004), social support (Brownson et al., 2001; Stahl et al., 2001) and access to shops and services (Duncan et al., 2005). King et al (2000) also demonstrated that observing others being active in the neighbourhood was positively associated with PA. Although our results seem consistent with these findings, direct comparisons should be taken carefully, because of differences in the design, outcome measures, age groups and statistical analysis.

Our methodological approach to address environmental variables (CATPCA) doesn't allow us to affirm that each of these items *per se* is related to PA. It can only be stated that if the participants of this study tended to agree with the most of the items that compose this dimension (i.e. have a positive overall perception) they have greater odds of achieving higher PA levels. However, CATPCA and logistic regression have major advantages, because it allows identifying the set of variables that are associated with PA and simultaneously to understand which environmental variables are correlated with each other. For example, in the dimension: Infrastructures, Access to destinations, Social environment and Aesthetics — it was possible to know that the existence of sidewalks was the variable more strongly correlated with the "… presence of shops […] within a walking distance…", with "…many places to go within a walking distance…" and with "… presence of several free or low cost recreation facilities" (data not shown).

The way that these variables combined and formed the dimension "Infrastructures, Access to destinations, Social environment and

Aesthetics" is interesting, because it reflects a mixture of several environmental characteristics. Probably the Azoreans value their physical and social environment in a particular way, suggesting a unique social and cultural background. This could imply that environmental interventions to promote PA among Azorean should consider these environmental variables as a cluster. Indeed, our data suggested that if some of these environmental features were not present, it might be possible that the existence of the other variables would not be enough to influence PA behaviour. Stressing the importance that addressing PA interventions at multiples levels can lead to more effective results.

Safety was not associated with PA levels, regardless of gender. It is possible that the majority of the participants in this study (regardless of their PA level) did not consider safety a problem. The percentage of respondents who disagreed with the questions that compose this dimension ranged from 49.6% (for the question regarding many four-way intersections in the neighbourhood) to 90% (for the question on crime during the day) (data not shown).

Different features of the physical and social environment may affect PA levels in men and in women distinctly. Few studies have examined gender differences in the relation between PA and perceived environmental attributes. Using the same questionnaire on perceived environmental attributes, in a sample of Canadian adults, Bengoechea et al. (2005) showed that social support was a significant predictor for leisure time PA in women; aesthetics was associated with leisure time PA in men and access to places for PA in both genders, although no significant relationships were found among women after adjustment for self-efficacy. Foster et al. (2004) reported, in English adults, that in men, walking ≥150 min/week was associated with access to a local park, whereas in women, walking was related with access to shops and safety during the day. Understanding differences between genders may be especially important because women systematically show lower PA levels.

Our results suggest that PA levels in women may be more influenced by the neighbourhood environment than in men, especially overweight/obese women. In fact, the dimension Infrastructures, Access to destinations, Social environment and Aesthetics was a significant predictor for both moderate PA and HEPA category only in women. When subjects were categorized by BMI status, the same dimension was a significant predictor of HEPA level in overweight/obese women, whereas in women with normal BMI this relation was not found. Focusing on gender differences, it is worthy to comment that more men than women were manual workers (43.6 vs. 25.2%) (data not shown) and therefore it is possible that most of their PA is work related and not necessarily done in the neighbourhood. But, because we used short version of the IPAQ (and as a result we calculated total PA), it is not possible to distinguish whether these PA is mostly work related or done in leisure time; we can only hypothesize it is predominantly work related. Nevertheless, these results allow us to speculate that if the environment is manipulated and becomes more activity-friendly it may have a greater impact on those at highest risk for inactivity: women, especially overweight/obese women (Brownson et al., 2000; Duncan and Mummery, 2005; Trost et al., 2002).

Due to the cross-sectional nature of this study, one should consider that the positive associations found between PA and activity-friendly environmental features may not reflect a long time exposure to this kind of environment in this population. On the other hand, people may choose to live in a particular type of neighbourhood according to their beliefs and attitudes toward PA.

Study limitations and strengths

The methodological procedures to address environmental variables (CATPCA) and the relations between environment and PA (Logistic Regression) do not allow us to affirm that each of the items that compose the dimension "Infrastructures, Access to destinations, Social environment and Aesthetics" *per se* is related to PA. However, these statistical approaches have major advantages, because they allow identifying the set of variables that are associated with PA and at the same time to understand which environmental variables are correlated with each other. Nevertheless, although our regression models fitted well (Homer and Lameshow goodness-of-fit Tests $p>0.05$), the proportions of the total variability of the outcome that were accounted for by the models were low (Nagelkerke R^2 ranged between 0.038 and 0.096 in the adjusted models), meaning that it is likely that other variables associated with PA behaviour, that we did not explore.

The generalization of the results of this study is limited due to the nature of our sampling design, which was not a random sampling strategy.

Our data relies on self-reported variables, which may result in an overestimation of behaviours considered positive, like PA and an underestimation of negative personal characteristics like weight status.

Future studies should consider the use of both objective and perceived measures of the environment to provide further knowledge in the relations between environmental characteristics and PA. Once perceptions of environmental attributes might be influenced by several lifestyle behaviours, personal beliefs and cultural values (Kirtland et al., 2003).

Conclusions

In Azorean women, the dimension "Infrastructures, Access to destinations, Social environment and Aesthetics" was positively associated with Moderate PA level and HEPA level. When subjects were categorized by BMI status, the same set of variables was a significant predictor of HEPA level in overweight/obese women. Safety was not associated with PA levels, regardless of gender.

Targeted programs for Azoreans aimed to increase PA levels should consider that Infrastructures, Access to destinations, Social environment and Aesthetics seem to act synergistically and are positively associated with PA levels, particularly in women.

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Paper V

Santos, R.; Vale, S..; Miranda, L. & Mota, J. **Socio-demographic and Perceived Environmental Correlates of Walking in Azorean Adults.** ***(submitted)***

Socio-demographic and Perceived Environmental Correlates of Walking in Portuguese Adults. A Multilevel Analysis.

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Abstract

Several studies have identified associations between walking levels and socio-demographic and environmental variables. The aim of the present study was to describe walking patterns and examine associations between socio-demographic characteristics and perceived environmental attributes with walking among adults living the Azorean Archipelago (Portugal). 7 330 adult participants (4 104 women), aged 38.1 ± 9.3 years, of the 2004 Azorean Physical Activity and Health Study. They answered the Environmental Module and the short version of the International Physical Activity Questionnaire. Among Azorean, the environmental dimension "Infrastructures, Access to Destinations, Social Environment and Aesthetics" and moderate to vigorous physical activity were positively associated with walking levels; and smoking, sitting time and being married were negatively related, regardless of gender, age or education level. Targeted programs for Azoreans aimed to increase walking levels should consider that Infrastructures, Access to Destinations, Social Environment and Aesthetics seem to act synergistically and associate positively with walking behaviour.

Key Words: Walking; IPAQ; Environmental Attributes; Azores.

Introduction

In adults, the lack of Physical Activity (PA) is recognized as a major health concern in most industrialized countries, due to its contribution to a multiplicity of negative health outcomes (Lee et al. 2001; Erlichman et al. 2002; Fang et al. 2003; Katzmarzyk et al. 2003).

Walking is regarded as one of the most popular leisure time PA pursuits in USA (Simpson et al. 2003) and in Europe (Vaz de Almeida et al. 1999), is a feasible way of travelling, a virtually cost free type of PA and is associated with several health benefits (Hu et al. 1999; Kelley et al. 2004; Weuve et al. 2004; Hamer and Chida 2008). Moreover, walking as a way to get to and from places or as a way of recreation or exercise may contribute significantly to adults' total PA (Rafferty et al. 2002; Simpson et al. 2003)

From an ecological point of view, PA behaviour can be seen as a result of an interaction between personal attributes and environmental factors (King et al. 2002). Research in this field has focused on availability and proximity of facilities for exercise and recreation (Humpel et al. 2002), physical features of the environment, neighbourhood safety, aesthetics and social organization of communities (Poortinga 2006).

Literature has identified positive relations between walking for particular purposes and activity-friendly environmental features (Owen et al. 2004). Although the evidence of the relation between PA or walking and environment is growing, most of the research has been carried out in USA and Australia. Consequently, studies in other settings are necessary, as it is not clear whether

the associations observed in those countries are generalizable to other populations (Ogilvie et al. 2008). Indeed, the limited variability of environmental attributes where the studies have been conducted is one of the limitations of this research area (Inoue et al. 2009).

The need to increase PA levels on a population basis is considered a public health priority. Therefore, to design and implement relevant policies and effective programs, it is essential to identify which set of environmental features provides potential opportunities for PA in general and for walking in particular, once changes in the environment may affect a large number of people on a relatively permanent basis.

Previous data has shown that the adults living in the Azorean Archipelago (Portugal) are characterized by a high prevalence of overweight and obesity, in both genders (Santos et al. 2008) and at the same time by PA levels that are comparable with the rest of the Europeans and the Portuguese living in the mainland (Santos et al. 2009). It is also known that the lack of PA affects mostly women, older and those with higher education level; and that, in women, especially overweight and obese women, PA levels seem to be influenced by a positive perception of some environmental attributes (Santos et al. 2008). But so far little is known about the factors that are particularly related to walking behaviour among Azoreans. In this context, the purposes of this study were twofold: (i) describe walking patterns and (ii) examine associations between socio-demographic characteristics and perceived environmental attributes with walking among Azoreans.

Methods

1. Study Design and Sampling

Data of the present study were derived from the Azorean Physical Activity and Health Study.

The Azorean Archipelago - Portugal, in the North Atlantic, comprises nine islands with a population of 240 024 people (INE 2003). The Azores is one of the seven "outermost regions" of the European Union (EU 1997) and has some unique geographical features and urban design that differ from the mainland. All of the islands have volcanic origins, numerous landscapes with virgin forest and green fields. Most of the urban areas are small and located on the coast. About 70% of the participants of this study lived in detached single-family houses. Tourism, fishing and agriculture are the most important occupations.

Study design, sampling and measures are reported elsewhere (Santos et al. 2008; Santos et al. 2008). Briefly, data collection was accomplished by mailing questionnaires to the adult residents of all islands. The questionnaires were sent through school children to their parents or relatives aged 18 or older. A response rate of 87.6% (14 017 questionnaires) was obtained. The study procedures were approved by the ethic committee of the University and written consent was obtained from all the participants.

For the present study, 7330 adults, aged 38.13±9.3 years old, for whom questionnaires contained complete information on PA, walking, environmental variables and anthropometric data, were included in the analysis.

2. Measures

2.1. Walking, Physical Activity and Sitting Time

Walking, Moderate and Vigorous PA (MVPA), total PA and sitting time were assessed with the International Physical Activity Questionnaire - short version (IPAQ) (Craig et al. 2003). Walking, MVPA and Total PA were expressed as minutes per week. MVPA was computed by summing the reported minutes per week of moderate and vigorous PA, excluding walking. Total PA computed by summing the reported minutes per week of MVPA and walking. Sitting time was expressed as minutes by day (IPAQ 2005).

Participants were classified as never walkers (no walking in the previous week); occasional walkers (walking for at least 10 min/week but less than 150 min/week); and, regular walkers (walking for 150 min/week or more).

2.2. Perceived Environmental Attributes

To assess perceived neighbourhood environments we administrated the Environmental Module of the International Physical Activity Prevalence Study questionnaire (IPS 2002).

The questionnaire has 17 questions about residential density; access to destinations; neighbourhood's infrastructures; aesthetic qualities; social environment; street connectivity; neighbourhood safety and number of household motor vehicles. The question about residential density has 6 response options: detached single-family housing; Townhouses, row houses, apartments or condos of 2-3 stories; Mix of single-family residences and

townhouses, row houses, apartments or condos; Apartments or condos of 4-12 stories; Apartments or condos of more than 12 stories; and Don't know/not sure. One question asked about how many motor vehicles there were at the household. The other 15 questions have a four-point Likert response scale: strongly disagree; somewhat disagree; somewhat agree; strongly agree and don't know/doesn't apply response option.

2.3. Socio-demographic and Anthropometric Variables:

Other self-reported variables included in this analysis were defined as follows:

(i) Education level – defined in accordance with the Portuguese Education System: group 1 (4 years' education); group 2 (5-9 years' education); group 3 (10-12 years' education) and group 4 (higher education).

(ii) Personal income per month – in group 1 (< 500 euros –minimal salary); group 2 (500 - 875 euros – about two minimal salaries/month); group 3 (>875 euros – more than two minimal salaries/month).

(iii) Smoking - Non smokers, former smokers (individuals who had stopped smoking for at least six months), occasional smokers (individuals who smoked less than one cigarette a day) and current smokers (individuals who smoked at least one cigarette a day) (WHO 1997). Occasional smokers were combined with current smokers due to their small sample size and coded as smokers; non smokers were combined with former smokers and coded as non smokers.

(iv) Alcohol Consumption - Non drinkers (no alcohol for more than twelve months), former drinkers (no alcohol for more than six months), occasional drinkers (individuals who drank less than one unit per week), regular drinkers (individuals who drank one to 10 units per week) and heavy drinkers (individuals who drank more than 10 units per week) (DepHealth 2004). Former drinkers were combined with non drinkers and coded as non drinkers; heavy drinkers, regular drinkers and occasional drinkers were combined and coded as drinkers.

(v) Marital Status – group 1: singles, separated, divorcees or widows. Group 2: married or living with a partner.

(vi) Number of Children per person - none; one child; two children and three or more children.

(vii) Body Mass index (BMI) - BMI was calculated as weight(kg)/height^2(m). Participants were divided in three categories: normal weight; overweight and obese (WHO 2000).

3. Statistical Analysis

Two-sided Student's T-test with Bonferroni adjustments was used to compare gender differences in continuous variables. Frequencies and Chi-Square Test were calculated for walking categories by socio-demographic and environmental variables.

To explore the relations between walking and each environmental variable we performed Spearman's correlations. Most of the activity-friendly environmental variables showed positive significant correlations with walking, in both genders (data not shown). Therefore, as done previously for this sample

(Santos et al. 2008), we conducted a Categorical Principal Components Analysis (CATPCA) in order to reduce the original set of environmental variables into a smaller set of uncorrelated components that represented most of the information found in the original variables, and at the same time, to understand the relationships between environmental variables. The results showed that only five dimensions derived from CAPTCA. The five dimensions explained 55.42% of the total variance, but only two dimensions (dimension 1: Infrastructures, Access to Destinations, Social Environment and Aesthetics; and dimension 2: Neighbourhood Safety) showed acceptable or good reliability (Cronbach' Alpha>0.6) and therefore indexes were constructed only for these dimensions. The index is an arithmetic average of the responses to the questions included in the dimension. In the dimension 1 a higher index means that participants tended to have a positive overall perception of the questions that compose the dimension; in the dimension 2 a lower index means that the participants consider their neighbourhood safe. For the bivariate analysis these indexes were divided in two categories based on the median value into "overall negative perception" and "overall positive perception". For the regression analysis the indexes were used as continuous variables.

To analyze the relation between walking, socio-demographic variables and environmental dimensions a series of Multilevel Linear Regression models were fitted to assess regression coefficients (β) and standard errors (SE) predicting walking. Subjects were nested in 3 levels: level 1 – subject; level 2 – municipality; level 3 – island of residence. In the construction of the Multilevel linear models we started by investigating intra-class coefficients from the

unconditional means model to estimate the proportion of the total variance in walking attributable to municipality differences (ICC=0.0017) as well as to island differences (ICC=0.0074). Subsequently, the models were constructed by adding simultaneously all independent variables (gender, age, BMI, MVPA, sitting time, marital status, number of children, education level, monthly income and both environmental dimensions). The random intercepts and random slopes for each independent variable, for both municipality and island, were investigated using a forward selection procedure. The final (best) model included the environmental dimensions, age, gender, education level, income per month, marital status, tobacco and alcohol consumptions, number of children, sitting time, MVPA and BMI. This model also included a random intercept for municipality, random slopes for municipality for BMI and total PA, and random slopes for island for total PA and for number of children.

Statistical analysis was performed using SPSS 15.0 and MLwin 2.0. The level of significance for all analysis was set at 0.05.

Results

The general sample features are shown in Table 1. The female participants of this study walked on average less than male participants (201.45 min/week vs 218.88 min/week; $p<0.05$). Walking accounted, on average, for 36.19% of the total PA.

Table 1 - Participants Characteristics.

	Total Sample **N=7330**	**Women** **N=4104**	**Men** **N=3226**	***p*[a]**
Age (mean ± SD)	38.13 ± 9.30	37.12 ± 8.9	39.42 ± 9.57	**<0.001**
Walking min/week (mean ± SD)	209.12 ± 259.01	201.45 ± 243.45	218.88 ± 277.27	**0.005**
Total PA min/week (mean ± SD)	464.6 ± 358.01	405.77 ± 347.41	539.42 ± 357.38	**<0.001**
Sitting Time min/week (mean ± SD)	252.32 ± 167.42	244.02 ± 160.9	262.87 ± 174.8	**<0.001**
%Walking in Total PA (mean ± DS)	36.19 ± 39.25	36.22 ± 39.33	36.16 ± 39.15	0.951

[a] - Based on T-Test Values, with Bonferroni adjustments.
SD - Standard Deviation. PA - Physical Activity.

As shown in Table 2, about one third of the Azorean walked at least 150 min/week. As age, the number of children and education level increases, the prevalence of never walkers also increases ($p<0.0001$ for all). Participants in the highest income category showed the lowest prevalence of regular walking. Only 11.9% of the regular drinkers and 23.7% of the smokers were regular walkers ($p<0.0001$ for both). About two thirds of the participants with an overall positive perception on environmental dimensions were occasional or regular walkers ($p<0.05$ for Infrastructures, Access to Destinations, Social Environment and Aesthetics; and $p<0.0001$ for Neighbourhood Safety).

Table 2 – Prevalence of walking by socio-demographic and environmental variables.

	Never Walkers		Occasional Walkers		Regular Walkers		p^a
	N	%	N	%	N	%	
Total Sample	2491	34%	2532	34.5%	2307	31.5%	**0.003**
Women	1382	33.7%	1437	35.0%	1285	31.3%	0.625
Men	1109	34.4%	1095	33.9%	1022	31.7%	
Age							
18-28 years	355	32.5%	410	37.5%	328	30.0%	**<0.0001**
28-38 years	772	31.5%	844	34.4%	837	34.1%	
38-48 years	1011	35.7%	917	32.4%	904	31.9%	
48-58 years	294	36.1%	314	38.5%	207	25.4%	
58-65 years	59	43.1%	47	34.3%	31	22.6%	
BMI							
Normal	992	32.9%	1084	36.0%	937	31.1%	0.080
Overweight	1056	35.1%	982	32.7%	968	32.2%	
Obese	443	33.8%	466	35.5%	402	30.7%	
Marital Status (Married/with partner)	2058	33.6%	2105	34.4%	1963	32.0%	0.053
Number of Children							
None	351	25.6%	541	39.5%	478	34.9%	**<0.0001**
1 child	532	34.4%	536	34.7%	478	30.9%	
2 children	1070	36.0%	974	32.8%	929	31.2%	
≥ 3 children	538	37.3%	481	33.4%	422	29.3%	
Education Level							
≤ 4years	765	37.2%	748	36.4%	543	26.4%	**<0.0001**
5-9 years	921	34.1%	928	34.4%	849	31.5%	
10-12 years	554	32.2%	596	34.6%	571	33.2%	
College/University	251	29.4%	260	30.4%	344	40.2%	
Monthly Income							
< 500 €	762	34.0%	770	34.4%	706	31.5%	**<0.0001**
500-875 €	1129	31.4%	1224	34.1%	1237	34.5%	
≥ 875 €	600	39.9%	538	35.8%	364	24.2%	
Smoking (Smokers)	767	43.1%	591	33.2%	422	23.7%	**<0.0001**
Alcohol Consumption (Drinkers)	323	60.3%	149	27.8%	64	11.9%	**<0.0001**
Dimension 1 – Infrastructures, Access to Destinations, Social Environment and Aesthetics (positive overall perception)	1332	35.3%	1277	33.9%	1163	30.8%	**0.047**
Dimension 2 – Neighbourhood Safety (positive overall perception)	1058	31.6%	1142	34.1%	1145	34.2%	**<0.0001**

[a] - Based on Chi-Square Test Value. BMI - Body Mass Index. Never Walkers - no walking in the previous week; Occasional Walkers - walking for at least 10 min/week but less than 150 min/week; Regular Walkers – walking for 150 min/week or more.

In Table 3, regression analysis showed that, MVPA and the dimension - Infrastructures, Access to Destinations, Social Environment and Aesthetics were significant positive predictors for walking (p<0.001 for both). Sitting time,

being married and being a smoker were found to be significant negative predictors for walking (p<0.001 for all).

Table 3 – Regression Coefficients and Standard Errors for Environmental Dimensions from the Multilevel Linear Regression Predicting Walking.

	β (SE)	***p****
Gender (men)	0.453 (6.225)	0.819
Age	-0.235 (0.397)	0.553
BMI	-0.334 (0.768)	0.663
MVPA	**0.120 (0.017)**	**<0.0001**
Sitting time	**-0.08 (0.019)**	**<0.0001**
Marital Status (Married/with partner)	**-32.487 (9.018)**	**<0.0001**
Number of Children (reference – none)		
One child	-8.794 (9.434)	0.351
2 children	-3.861 (8.357)	0.644
≥ 3 children	-12.127 (13.116)	0.355
Education Level (reference – 4 years)		
5-9 years	1.069 (8.013)	0.893
10-12 years	-8.408 (9.670)	0.385
College/University	-20.735 (10.932)	0.057
Monthly Income (reference – < 500 €)		
500-875 €	2.843 (6.819)	0.676
≥ 875 €	0.912 (8.497)	0.914
Smoking (Smokers)	**-20.72 (7.039)**	**0.003**
Alcohol Consumption (Drinkers)	-8.991 (11.690)	0.442
Dimension 1 – Infrastructures, Access to Destinations, Social Environment and Aesthetics (positive overall perception)	**27.050 (4.836)**	**<0.0001**
Dimension 2 – Neighbourhood Safety (positive overall perception)	-7.681 (5.573)	0.168

* – p values based on the Wald Test. SE – Standard Error. β – Regression Coefficients.
BMI - Body Mass Index. MVPA - Moderate and Vigorous Physical Activity (excluding walking).

Discussion

To our knowledge, this is the first study addressing relationships between socio-demographic characteristics and perceived environmental attributes with walking among Azoreans.

Our study extends the findings of previous studies by demonstrating that walking is an important contributor for people's meeting the recommendations for PA, as walking represents on average 36.19% of the total PA (Rafferty et al. 2002; Simpson et al. 2003). About one third of the Azoreans walked at least 150 min/week and as expected, this prevalence varied little between men and women (Eyler et al. 2003; Reis et al. 2008).

Several IPAQ studies have found significant relations between socio-demographic variables and walking levels. Consistent with our results (in the adjusted regression model) others did not find significant associations between walking levels and age (Cole et al. 2006; Sjöström et al. 2006), gender (Sjöström et al. 2006), education level (Hagströmer et al. 2006; Sjöström et al. 2006) and BMI (Cole et al. 2006), highlighting the acceptability and accessibility of walking among Azoreans from all stratum. Nevertheless, our findings are also in contrast with other IPAQ-walking studies, Hallal et al (2005) showed positive associations between walking, male gender and education level (Hallal et al. 2005); Hagstomer et al (2006) demonstrated an inverse relation between walking and BMI as well as a positive association between walking and age (Hagströmer et al. 2006); Cole et al (2006) found positive associations between

walking and education level. These similarities and differences may suggest culture and social diversity (Cole et al. 2006) .

Similarly to what Hagströmer et al (2006) found in Swedish men, being married/living with a partner was a negative predictor of walking behavior. As associations between marriage and PA or walking have not been reported for Portugal comparisons are not possible. Nevertheless, it is possible that some culture factors and traditions among Azorean may play an important role in this relation between marriage and walking. In fact, literature has produced mixed results about the association between marital status and PA (Trost et al. 2002). Some authors hypothesize that time pressures of juggling career and family responsibilities have a great impact on women and significantly reduces their leisure-time (Brown and Trost 2003).

In addition to socio-demographic correlates, our results showed that the environmental dimension Infrastructures, Access to Destinations, Social Environment and Aesthetics was a significant positive predictor for walking. Previous research using perceptions of environmental attributes and self-reported total walking has shown positive associations between higher total walking levels and presence of sidewalks (Eyler et al. 2003; Addy et al. 2004) or walking trails (Eyler et al. 2003); number of walking routes (Granner et al. 2007); high residential density (Inoue et al. 2009); enjoyable scenery (Eyler et al. 2003) or attractive open spaces (Giles-Corti and Donovan 2003); awareness of places to walk and convenience of the walking place (Powell et al. 2003); access to a local park (Foster et al. 2004; Granner et al. 2007); access to shops (Inoue et al. 2009); car parking difficulty (availability of parking spaces or its

costs) (Rodriguez et al. 2008) and social support (Eyler et al. 2003) or having physically active neighbours (Addy et al. 2004). In 2004, a review by Owen et al. found that convenience of facilities for walking and accessibility of destinations (such as convenience of biking or walking trails, stores in walking distance) were associated with total walking (Owen et al. 2004). In general, our findings are consistent with most of the existing literature, although, direct comparisons should be taken carefully, because of differences in the design, outcome measures, age groups, and most of all the statistical techniques applied, as we referred in a previous analysis with this Azorean sample (Santos et al. 2008).

The way that these variables combined and formed the dimension "Infrastructures, Access to Destinations, Social Environment and Aesthetics" is interesting, because it reflects a mixture of several environmental characteristics. Probably the Azoreans value their physical and social environment in a particular way, suggesting a unique social and cultural background. This could imply that environmental interventions to promote walking among Azorean should consider these environmental variables as a cluster. Indeed, our data suggested that if some of these environmental features were not present, it might be possible that the existence of the other variables would not be enough to influence walking behaviour. Stressing the importance that addressing PA interventions in general and walking interventions in particular, at multiples levels can lead to more effective results.

In our study the environmental dimension Neighbourhood Safety was not associated with walking. Certainly, because the majority of the participants in

this study (regardless of their walking level or gender) did not consider safety a problem. The percentage of respondents who disagreed with the questions that compose this dimension ranged from 49.6% (for the question regarding many four-way intersections in the neighbourhood) to 90% (for the question on crime during the day) (data not shown). In fact, literature about perceived safety and PA or walking is inconsistent and to date the evidence is insufficient to conclude that crime-related safety influences PA (Foster and Giles-Corti 2008).

Study Limitations and Strengths

Due to the cross-sectional nature of this study, one should recognize that the positive associations found between walking and activity-friendly environmental features may not reflect a long time exposure to this kind of environment in this population. On the other hand, people may choose to live in a particular type of neighbourhood according to their beliefs and attitudes toward PA in general and walking in particular. In fact, we did not control our results for self selection of the neighbourhood (Owen et al. 2007). Nevertheless, ones should bear in mind the challenges of measuring area level context. In the interpretations of cross-sectional ecological studies, there is a need to acknowledge that data are fixed in space and time, and that there might be a possible “lag effect”, i.e. changes in health outcomes may be measurable only after a substantial period of time has elapsed and in many cases it is not plausible to expect immediate change in health outcomes (Cummins et al. 2005).

The methodological procedures to address environmental variables (CATPCA) and the relations between environmental characteristics and walking (Multilevel linear regression) do not allow us to affirm that each of the items that compose the dimension Infrastructures, Access to Destinations, Social Environment and Aesthetics *per se* is related to walking. However, these statistical approaches have major advantages, because they allow identifying the set of variables that are associated with walking and at the same time to understand which environmental variables are correlated with each other. An additional strength of this study is that it was carried out in an interesting, different and unique environment, with a distinct social and cultural background – the Azorean Archipelago – with a population about whish not much is known, since no data on walking patterns and associated variables had been reported so far.

The generalization of the results of this study is limited due to the nature of our sampling design, which was not a random sampling strategy.

Our data relies on self-reported variables, which may result in an overestimation of behaviours considered positive, like PA and walking and an underestimation of negative personal characteristics like weight status.

Future investigations should consider the use of both objective and perceived measures of the environment to provide further knowledge in the relations between environmental characteristics and walking. Future studies in this population may also consider exploring several walking behaviours (active travel, leisure time or exercise) as different variables might correlate with different types of walking (Owen et al. 2004; Giles-Corti et al. 2005). Upcoming

research in this population might also perspective the current debate about the context-specific behavioral outcome measure and the inclusion of environmental correlates that are specific to the behavioral outcome of interest (Giles-Corti et al. 2005). Once the predictive capacity of the models appear to improve when environmental measures more closely match the behavior of interest and the setting in which the behavior takes place, as well as, if a greater specificity were introduced by using context-specific measures of behavior (Giles-Corti et al. 2005).

Conclusions

Among Azorean, the environmental dimension “Infrastructures, Access to Destinations, Social Environment and Aesthetics” and MVPA were positively associated with walking levels; and smoking, sitting time and being married were negatively related, regardless of gender, age or education level. Targeted programs for Azoreans aimed to increase walking levels should consider that Infrastructures, Access to Destinations, Social Environment and Aesthetics seem to act synergistically and associate positively with walking behaviour.

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5.Main Findings, Study Limitations and Conclusions

1. Main Findings, Study Limitations and Conclusions

The APAHS provides, for the first time, a general idea of the PA and obesity prevalence and related lifestyle behaviours and demographic characteristics in a large sample of Azorean adults. This study also highlights the relationships between perceived environmental attributes and PA or walking among Azoreans adults.

The overweight and obesity prevalences among Azoreans are high, particularly in men (33.9 and 18.7% in women, and 45.9 and 16% in men, respectively). Overall, among Azorean adults 56.4% had a BMI $\geq$ 25 Kg/m^2. Advanced age was a predictor of overweight and obesity and smoking status was negatively associated with BMI, in both genders, which is consistent with previous studies. An inverse association between socio-economic status and obesity and between alcohol consumption and overweight was found in women, but not in men. Men with low PA levels and higher sitting time were more likely to be obese.

There is a significant proportion of Azoreans, particularly the older and women that do not do enough PA to attain health benefits. In our study, the compliance with HEPA report, suggests that the prevalence of active individuals was 32.2%. These findings are comparable with the average prevalence across European Union countries (29%) and with the Portuguese prevalence (33.1%); However, the differences observed between genders among the Azoreans (23.6% in women and 43.8% in men) are more pronounced when compared with the Portuguese participants of the Eurobarometer Study (29.8% in women and 36.9% in men) [182]. Considering the new 2007 ACSM/AHA PA guidelines, the prevalence of active participants is 57.1% (48.3% for women and 68.8% for men, $p<0.001$).Our findings also showed that 40% of women reported No PA/week. More women than men showed No PA/week ($p<0.001$), No vigorous PA/week ($p<0.001$) and Low PA level ($p<0.001$). Men had higher prevalence of sitting for more than 3h/day ($p<0.001$).

Considering that the Azorean Archipelago is one of the outermost regions of the European Union and that about 70% of the participants in this study had no more than 9 years of education, the negative associations found between income per month and education level with HEPA level, as well as, the prevalence of HEPA level and sitting time observed, we can speculate that PA levels in this population are mostly work-related and that leisure time PA may not be a frequent behaviour. But the use of the short version of the IPAQ does not let us verify this supposition. In fact, IPAQ short version measures all PA domains but it does not differentiate them. Future studies in the Azorean population could consider the use of the long version of the IPAQ in order to confirm or to rule out this hypothesis. Since some studies (that did not used IPAQ to measure PA) have shown that low socio-economic position is a negative predictor for leisure time PA [154, 159, 221-223] and others revealed that Portugal has one of the lowest leisure time PA prevalence in Europe [7, 159, 160].

Several studies from different countries have documented PA levels of the adult population; however it is somewhat difficult to compare studies, considering the variety of methods used to measure PA and the PA domain assessed. Due to feasibility constraints and economic costs, most of the epidemiological studies have used questionnaires; however the use of different questionnaires makes comparisons difficult. On the other hand, leisure-time PA has been one of the most frequently assessed domains of PA, but, current PA guidelines for adults emphasize total PA, not only leisure time PA. The IPAQ was developed to overcome these limitations, i.e.: a standardized questionnaire, translated into different languages, which covers all the PA domains and therefore allows comparisons between studies and populations. In the APAHS, the short version of the IPAQ was chosen to measure PA levels not only due to feasibility concerns, but also to be possible to compare the Azorean PA levels with other populations.

After adjustments, walking was not a significant predictor for BMI, in either gender. Although the cross sectional nature of this study does not allow casual relationships to be determined, our data suggest that walking per se may

not increase energy expenditure sufficiently to prevent high BMI, after adjustments for cofounders. Nevertheless, obese individuals may benefit more from their walking time than normal weight participants and therefore walking should be encouraged. In our study we did not assess the intensity of walking, which may be an important feature that differentiate walking patterns in normal weight and overweight/obese individuals. Nonetheless, based on previous research, it is possible that our overweight/obese subjects may have had greater cardiovascular benefits from walking than normal weight subjects, for the same walking time and intensity.

In Azorean women, a positive overall perception of the environmental dimension “Infrastructures, Access to Destinations, Social Environment and Aesthetics” was positively associated with Moderate PA level and HEPA level. When subjects were categorized by BMI status, the same set of variables was a significant predictor of HEPA level in overweight/obese women. This same dimension was positively associated with walking behaviour, regardless of gender. Safety was not associated with PA or walking levels, regardless of gender.

Our results seem consistent with previous findings from the literature on environment and its relation with PA or walking, but direct comparisons should be taken carefully, because of the differences in the design, outcome measures, age groups and statistical analysis.

Our methodological approach to address environmental variables (CATPCA) does not allow us to affirm that each of these items *per se* is related to PA or walking. It can only be stated that if the participants of this study tended to agree with most of the items that compose this dimension (i.e. have a positive overall perception) they have a good probability of achieving higher PA or walking levels. However, CATPCA and logistic regression have major advantages, because it allows to identify the set of variables that are associated with PA or walking and simultaneously to understand which environmental variables are correlated with each other. The way these variables combined and formed the dimension “Infrastructures, Access to Destinations, Social

Environment and Aesthetics" is interesting, because it reflects a mixture of several environmental characteristics. Probably the Azoreans value their physical and social environment in a particular way, suggesting a unique social and cultural background. This could imply that environmental interventions to promote PA among Azorean should consider these environmental variables as a cluster. Indeed, our data suggested that if some of these environmental features were not present, it might be possible that the existence of the other variables would not be enough to influence PA behaviour. Stressing the importance of addressing PA interventions at multiple levels can lead to more effective results.

Due to the cross-sectional nature of this study, one should consider that the positive associations found between PA and activity-friendly environmental features may not reflect a long time exposure to this kind of environment in this population. On the other hand, people may choose to live in a particular type of neighbourhood according to their beliefs and attitudes toward PA. Nevertheless, these results allow us to speculate that if the environment is manipulated and becomes more activity-friendly it may have a greater impact on those at highest risk for inactivity: women, especially overweight/obese women

This study is not without limitations. First, the use of questionnaires may have biased our results. The use of self-reported variables might have resulted in an overestimation of behaviours considered to be positive, like PA and in an underestimation of the negative ones, like body mass, alcohol consumption and smoking status. BMI based on self-report data, could indicate an underestimation of the true prevalence of overweight and obesity. Second, this study did not collect any information on the duration of obesity, PA habits, and if the participants were currently trying to lose weight. Third, we did not assess dietary habits. Fourth, the short form of the IPAQ was chosen to measure PA levels in this population, but future studies might consider the use of the long form of this questionnaire, in order to understand better PA patterns by PA domain (i.e. work related PA, transportation PA, housework PA and leisure time PA). Fifth, the generalization of the results of this study is limited due to the

nature of our sampling design, which was not a random sampling strategy. Finally, this is a cross-sectional study and therefore no casual relationships can be drawn.

Despite the limitations of our study, the results suggest that promoting healthy lifestyles may contribute to decrease the prevalence of overweight and obesity**.** Targeted programmes for Azoreans should focus on the elderly; on women with low socio-economic status, and on men aged 26-40 years due to the higher prevalence of overweight and obesity and low levels of PA observed in these groups along with more universal interventions as a way of reaching everyone at the same time.

Our results also suggest that targeted programs for Azoreans aimed to increase PA levels should pay special attention to women, and consider a multi-factorial approach, as several lifestyle behaviours and socio-demographic characteristics seem to interact with PA and walking levels in this population.

From a public health point of view, strategies to promote PA among the Azorean adults could encourage walking behaviour, due to its health benefits. Walking is a safe, accessible and virtually cost free form of PA. Walking, as any other form of moderate PA, can be more readily adopted and maintained throughout the lifetime than vigorous PA. Walking, as a way to commute, provides a feasible method of integrating PA into modern lifestyles.

Future studies should consider the use of both objective and perceived measures of the environment to provide further knowledge of the relations between environmental characteristics and PA or walking, once perceptions of environmental attributes might be influenced by several lifestyle behaviours, personal beliefs and cultural values.

Among Azoreans regular surveillance is required in order to monitor, study trends over time and analyze the population subgroups that are most affected by the lack of PA, obesity and other health related outcomes. Future studies may also offer guidance for PA promotion programs.

6.References

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