HORMONES 2013, 12(2):265-274

Research paper

Association of physical activity and sedentary lifestyle patterns with obesity and cardiometabolic comorbidities in Greek adults: Data from the National Epidemiological Survey

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ABSTRACT

OBJECTIVE: To investigate the association between physical activity (PA) and sedentary lifestyle (SL) patterns with overweight (OW), obesity (OB), abdominal obesity (AO) and cardiometabolic comorbidities in Greek adults based on data from the National Epidemiological Survey for the prevalence of obesity. DESIGN: Cross-sectional epidemiological survey. Participants were selected via stratified sampling. 17,887 men and women, 20-70 years old, underwent anthropometric measurements for the estimation of OW, OB and AO prevalence. Assessment of PA, SL patterns and metabolic comorbidities was performed using an in-home questionnaire allowing self-evaluation of diverse activities and self-report for the presence of hypercholesterolemia (HCE), type 2 diabetes mellitus (T2DM) or hypertension (HTN). RESULTS: In men, even small amounts of walking were associated with decreased risk of being OW and AO, while larger amounts were associated with decreased risk of being OB. In women, engagement in entertainment activities for more than 4 hours per week was associated with less risk of being OW. Concerning cardiometabolic comorbidities, substantial improvement was evident mainly for men, e.g. signfiicantly reduced risk for HCE, T2DM and HTN by frequent engagement in exercise. On the other hand, frequent TV watching and long hours of office work significantly increased the risk of HCE and HTN in men. CONCLUSIONS: In Greek adults, and men in particular, walking activity was significantly associated with lower risk for obesity. In addition, frequent exercise and less sedentary behaviour were associated with reduced risk for cardiometabolic factors, mainly hypercholesterolemia and hypertension.

Key words: Abdominal obesity, Greek adults, Metabolic comorbidities, Obesity, Physical activity, Prevalence

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Received 31-07-2012, Accepted 10-04-2013

INTRODUCTION

There is a worldwide increase in the prevalence of overweight (OW) and obese individuals (OB), with OB becoming a major public health problem.[1] In developed as well as in developing societies, obesity predisposes to life-threatening chronic diseases, such as cardiovascular disease (CVD), type 2 diabetes mellitus (T2DM), hypertension (HTN), dyslipidemia and cancer, and thereby contributes to premature mortality.[1,2] While genes may serve as predictors of obesity, there is, however, a strong environmental effect on the phenotypic expression of genes. Thus, subjects with genetic predisposition to obesity become obese only when exposed to an unhealthy lifestyle, including unwholesome diet and/or inactivity.[3]

Energy expenditure of ~2000Kcal per week has been proposed as a contributor to longevity and a protective "shield" against CVD.[4] Nevertheless, modernization, industrialization and the subsequent automatization of everyday life have considerably decreased manual work and have resulted in the overwhelming majority of people leading a sedentary way of life. Despite its apparent appeal, this lifestyle has brought about a detrimental reduction of energy expenditure.[5] TV watching has also been associated with obesity due not only to decreased energy expenditure but also to increased energy intake induced by the consumption of fat- and sugar-rich foods during this inactivity.[6]

By stark contrast, physical activity (PA) leads to a negative energy and fat balance, as it increases energy expenditure and, more specifically, fat oxidation, since it is well known that insufficient fat oxidation is correlated with obesity. Apart from prevention of obesity, exercise plays a crucial role in the prevention of cardiometabolic risk factors such as T2DM, dyslipidemia and HTN, and, as it has repeatedly been shown, cardiovascular disease.[7] Intense aerobic exercise (such as fast walking, jogging, racket games, cycling or swimming) during leisure time has been found to protect against coronary heart disease (CHD) and heart attacks in middle- and old-aged subjects.[7]

The majority of recent studies shows that a high percentage of individuals living in developed societies adopt a sedentary lifestyle (SL). Nearly 30% of the English population[3] reports little or no leisure-time physical activity, while the corresponding percentage in the USA amounts to 50%.[8] In Greece, during the last few decades, there has been a dramatic shift from manual work to non-manual office work.[9] It has previously been reported that 50% of the Greeks who live in the prefecture of Attica were physically inactive, with men being more active than women.[10] In a study across nine European countries, only 30% of women and 50% of men were active or moderately active.[11] The aim of the present study was to examine the association between PA and SL patterns and the prevalence of overweight and obesity as well as their metabolic comorbidities, such as T2DM, hypercholesterolemia (HCE) and HTN in Greek adults. To the best of our knowledge, no study to date has examined these associations in an extended sample of a Greek population.

SUBJECTS AND METHODS

In this study, we analyzed data concerning physical activity patterns and metabolic comorbidities taken from the first nationwide cross-sectional epidemiological survey, conducted in 2003, for the prevalence of obesity in Greek adults. The survey was performed by experienced physicians, all members of the Hellenic Medical Association for Obesity (HMAO), with the approval and collaboration of the Greek Ministry of Education. The survey was approved by the ethics committee of the Technological Educational Institute of Thessaloniki (Ref. No 20102).

The methodology used in the study has been described in previous papers.[12,13] Briefly, the selection of participants was conducted by proportionate stratified random sampling (SRS) through household family members of Greek adolescent (13-19yrs) students of public schools throughout the country. Each adolescent was provided with an envelope containing an in-home questionnaire for all household relatives. Adolescents received training on anthropometric techniques by physical training instructors, following standardized criteria, in order to be able to take measurements of their relatives at home. Therefore, their adolescent children measured most adult participants for obesity indices. Other subjects, such as young unmarried adults, aged 20-35 (uncles, aunts, older siblings), who lived in the same house, also took part.

Anthropometric measurements included height, body weight, waist and hip circumference. Weight was measured to the nearest 0.1 kg with the same kind of portable scale (Terraillon T 715, Terraillon France, France) and the participant in minimal clothing. Height was measured to the nearest 0.1 cm without shoes. Body mass index (BMI) was calculated as body weight (Kg) divided by squared height (m^2). Waist circumference (WC) was measured with a tape at the mid-distance between the top of the iliac crest and the bottom of the rib cage. BMI was categorized according to the World Health Organization[2] standards: normal weight: <25 kg/m^2, overweight: 25 - 29.9 kg/m^2 and obese: >30 kg/m^2. Abdominal obesity was defined as waist circumference more than 102 cm in men and 88 cm in women.[14]

All participants were invited to complete a self-reported questionnaire designed to assess PA and health status. Subjects were asked two types of questions in order to assess PA/exercise and SL levels on a weekly basis via:

a) self-assessment of the weekly amount of time spent on walking and organized exercise, i.e. in gyms or sport centers;

b) self-evaluation of the time spent on TV watching, working in an office or at a workplace requiring sedentary (sitting) time, as well as time spent for entertainment (going to a cinema, restaurant, café, bar).

In accordance with the associations established by Aadahl et al,[15] walking and exercise were grouped into the following categories: <2h/week, 2-3.9h/week, 4-6.9h/week and ≥7h/week.

Cardiometabolic health status was ascertained in all participants through self-reported physician-diagnosed presence or absence of T2DM, HCE and HTN (Question asked: Have you ever been diagnosed by your physician as having diabetes, high cholesterol levels or high blood pressure?).

The non-response rate (including incorrect values) for the variables included in the analysis was as follows: Body Weight, 2.3%; Height, 2.5%; Waist Circumference, 4.6%; PA patterns, 2.2%; Presence of metabolic comorbidities, 2.5%. From a total estimated number of 22,147 subjects, 17,887 adults were available for the final analysis (valid participation rate 80.76%; 8,423 men and 9,464 women). The overall mean age and standard deviation (± SD) was 43.4±19.1 years (44.4±25, for men; 41.3±11.5 for women).

Statistical Analysis

Multiple binary logistic regression analyses were performed to determine the association between walking, exercise, TV watching, office work and entertainment and OW, OB, AO as well as various metabolic comorbidities. An independent sample t-test was performed to compare BMI results between genders. The odds ratios were calculated for all dependent factors using a confidence level of 95%. Interactions between factors entered in the logistic regression models were also examined. Values of $p<0.05$ were considered to be statistically significant. Statistical analyses were performed using Minitab v15.

RESULTS

The mean BMI of the total study population was 26.5±5.3 and was higher in men than in women (27.3±4.9 vs 25.7±5.1, $p<0.001$). The mean value of waist circumference was 90 cm (95.3 cm for men, 85.4 cm for women, $p<0.001$). The overall prevalence of OB was 22.3% (25.9% in men, 19.2% in women), of OW 35.2% (41% in men, 29.8% in women) and that of AO 26.9% in men and 35.5% in women. More details of the sample's anthropometric characteristics have been reported in a previous publication.[12] The most frequently reported metabolic disturbance of the study population was HCE (13.3% overall, 12.6% in men, 8.2% in women), followed by HTN (8.6% overall, 9.4% in men, 7.9% in women) and T2DM (4.2% overall, 4.7% in men, 3.6% in women). Regarding PA parameters, almost 37% of subjects reported walking less than 2 hours/week and 90% of them exercised less than 2 hours/week. Additionally, more than 1/3 of the study population reported that their entertainment time was longer than 4 hours/week. When practices of sedentary lifestyle were analyzed, 37.9% of the subjects (37.8% of men, 37.9% of women) reported watching TV for more than 16 hours/week and 20.5% of the subjects (24.5% of men, 16.9% of women) reported doing office work for more than 14 hours/week. The prevalence of OB, AO, comorbidities and features of PA of the study population according to gender are presented in Table 1.

Table 1. Prevalence of obesity, abdominal obesity, metabolic comorbidities and features of physical activity of the study population and according to gender

	Total (%)	Males (%)	Females (%)
Obesity status			
Normal	42.4	33.1	50.9
Overweight	35.2	41.1	29.8
Obese	22.3	25.9	19.2
Abdominal obesity			
Absence		73.1	64.5
Presence		26.9	35.5
Comorbidities			
Diabetes	4.2	4.7	3.6
Hypercholesterolemia	13.3	12.6	8.2
Hypertension	8.6	9.4	7.9
Walking			
<2 hrs/week	36.9	37.4	36.6
2 – 3.9 hrs/week	16.9	14.9	18.7
4 – 6.9 hrs/week	13.8	12.1	15.3
≥7 hrs/week	32.4	35.5	29.4
Exercise			
<2 hrs/week	90.3	91.3	89.4
2 – 3.9 hrs/week	4.4	2.9	5.6
4 – 6.9 hrs/week	3.3	3.3	3.4
≥7 hrs/week	2.2	2.5	1.6
TV watching			
<16 hrs/week	62.1	62.2	62.1
≥16 hrs/week	37.9	37.8	37.9
Office work			
<14 hrs/week	79.5	75.5	83.1
≥14 hrs/week	20.5	24.5	16.9
Entertainment			
<4 hrs/week	66.3	59.3	72.6
≥4 hrs/week	33.7	40.7	27.4

In men, walking between 2 to 3.9 hours per week decreased the risk of OW and AO by 15% and 14%, respectively ($p<0.05$). Moreover, walking for more than 7 hours per week decreased the likelihood of OB by 12% ($p<0.05$). Exercise, entertainment, TV watching and office work were not found to be associated with OW, AO or OB. Table 2 presents the odds ratio of OW, OB and AO by different PA patterns in men.

In women, entertainment for more than 4 hours per week decreased the risk of OW by 8%, ($p<0.05$), while walking, exercise, TV watching and office work were not found to be associated with OW, AO or OB (Table 3).

Table 4 shows the odds ratio of the reported presence of HCE, T2DM and HTN by different PA patterns and indices of sedentary lifestyle in men. Exercise for more than 7 hours per week decreased HCE risk by 55% ($p<0.05$). On the other hand, TV watching for more than 16 hours per week and office work longer than 14 hours per week increased the risk of HCE by 20% ($p<0.05$) and 55% ($p<0.001$), respectively. Concerning T2DM, we found that exercising between 4 to 6.9 hours/week decreased odds ratio 70% ($p<0.05$). Walking, TV watching, office work and entertainment did not affect the risk of T2DM. Exercising between 4 to 6.9 hours/week reduced by half HTN presence ($p<0.05$). By contrast, TV watching for more than 16 hours per week and office work longer than 14 hours per week increased the risk of HTN by 36% ($p<0.001$) and 33% ($p<0.05$), respectively.

In women, PA patterns were not associated with any cardiometabolic risk factor (Table 5). TV watching alone, for more than 16 hours per week, increased the risk for HTN presence by 33% ($p<0.05$). Additionally, office work, for more than 14 hours per week, appeared to decrease the likelihood of T2DM by 36% ($p<0.05$).

DISCUSSION

This cross-sectional study is the first to report on the association of exercise and sedentary lifestyle patterns with OB and its metabolic comorbidities in an extended sample covering all the Greek territory. According to our findings, this applying only to men, even small amounts of walking were associated with decreased risk of being OW and AO, while large amounts of walking were associated with decreased risk of being OB. In women, only engagement in entertainment activities for more than 4 hours per week was associated with decreased risk of being OW. Concerning cardiometabolic comorbidities, substantial improvements were evidenced mainly in men: risk for HCE,T2DM and HTN was significantly reduced by frequent exercise practices, while risk of

Table 2. Odds ratio of overweight, obesity and abdominal obesity by different physical activity patterns in men

	Overweight		Obesity		Abdominal obesity	
Predictor	**Odds Ratio (95%CI)**	**P**	**Odds Ratio (95%CI)**	**P**	**Odds Ratio (95%CI)**	**P**
Age group						
18-39	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
40-65	1.96 (1.70-2.26)	**<0.001**	1.68 (1.44-1.96)	**<0.001**	2.20 (1.93-2.51)	**<0.001**
>65	1.75 (1.31-2.33)	**<0.001**	1.70 (1.29-2.25)	**<0.001**	2.18 (1.68-2.83)	**<0.001**
Walking						
<2 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
2 – 3.9 hrs/week	0.85 (0.73-1.00)	**0.050**	0.89 (0.76-1.04)	0.143	0.86 (0.74-1.00)	**0.049**
4 – 6.9 hrs/week	0.96 (0.81-1.15)	0.663	0.92 (0.78-1.09)	0.338	0.95 (0.81-1.12)	0.562
≥7 hrs/week	0.95 (0.84-1.08)	0.414	0.88 (0.78-1.00)	**0.044**	0.96 (0.86-1.07)	0.466
Exercise						
<2 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
2 – 3.9 hrs/week	1.21 (0.89-1.65)	0.233	0.93 (0.68-1.28)	0.674	1.12 (0.84-1.51)	0.435
4 – 6.9 hrs/week	0.89 (0.66-1.19)	0.425	0.91 (0.67-1.24)	0.561	1.09 (0.83-1.43)	0.555
≥7 hrs/week	1.17 (0.85-1.63)	0.339	0.70 (0.48-1.03)	0.071	0.96 (0.70-1.32)	0.816
TV watching						
<16 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥16 hrs/week	1.04 (0.92-1.18)	0.531	0.96 (0.88-1.05)	0.556	0.94 (0.84-1.06)	0.306
Office work						
<14 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥14 hrs/week	0.95 (0.83-1.07)	0.390	0.93 (0.82-1.05)	0.246	1.02 (0.91-1.14)	0.765
Entertainment						
<4 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥4 hrs/week	0.98 (0.88-1.10)	0.749	0.98 (0.88-1.10)	0.774	0.97 (0.87-1.07)	0.502

HCE and HTN increased by frequent TV watching and office work.

This study has also confirmed previous data showing low levels of PA among the Greek population. Only 1/3 of Greek adults reported walking more than 7 hours per week and the vast majority of the subjects (90%) reported exercising less than 2 hours per week. In the ATTICA study, half of the studied population of both genders reported being physically inactive.[10]

We herein report that regular walking for more than 2 hours per week was inversely associated with a risk of being overweight and abdominally obese, while walking for more than 7 hours per week was associated with a risk of being totally obese. These associations were found only in men, this discrepancy possibly being explained by the higher metabolic rate (per kg of body weight) of men which is due to their larger lean body mass.[16] It could be assumed that women need to walk more time than men in order to reduce the risk of excess body fat. In women, only engagement in entertainment activities for more than 4 hours per week was associated with decreased risk of being overweight which, to the best of our knowledge, is a novel finding. It could be attributed to the fact that outdoor activities, such as going out with friends to restaurants, cafés, and bars are linked to a better balance control, thus helping individuals to keep their weight at a lower level. The reverse etiology is also possible, i.e., normal-weighted subjects have more active social life than their obese counterparts.

One of the very limited Greek studies that have

Table 3. Odds ratio of overweight, obesity and abdominal obesity by different physical activity patterns in women

	Overweight		Obesity		Abdominal obesity	
Predictor	**Odds Ratio (95%CI)**	**P**	**Odds Ratio (95%CI)**	**P**	**Odds Ratio (95%CI)**	**P**
Age group						
18-39	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
40-65	1.46 (1.32-1.62)	**<0.001**	1.82 (1.61-2.06)	**<0.001**	1.72 (1.56-1.89)	**<0.001**
>65	2.13 (1.68-2.70)	**<0.001**	4.57 (3.73-5.59)	**<0.001**	4.71 (3.62-6.13)	**<0.001**
Walking						
<2 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
2 – 3.9 hrs/week	0.96 (0.83-1.10)	0.535	0.97 (0.83-1.13)	0.679	0.98 (0.85-1.12)	0.720
4 – 6.9 hrs/week	1.00 (0.86-1.16)	0.994	1.06 (0.90-1.25)	0.493	1.10 (0.95-1.27)	0.211
≥7 hrs/week	0.96 (0.85-1.08)	0.482	1.05 (0.92-1.21)	0.463	1.00 (0.89-1.12)	0.938
Exercise						
<2 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
2 – 3.9 hrs/week	1.02 (0.82-1.26)	0.855	1.01 (0.79-1.29)	0.922	1.05 (0.86-1.29)	0.634
4 – 6.9 hrs/week	0.80 (0.61-1.07)	0.131	0.95 (0.69-1.32)	0.775	1.02 (0.78-1.32)	0.889
≥7 hrs/week	0.90 (0.59-1.37)	0.626	1.43 (0.94-2.18)	0.096	1.10 (0.75-1.61)	0.624
TV watching						
<16 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥16 hrs/week	0.95 (0.85-1.06)	0.364	0.96 (0.84-1.09)	0.490	0.91 (0.79-1.04)	0.254
Office work						
<14 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥14 hrs/week	0.94 (0.82-1.07)	0.345	0.91 (0.78-1.07)	0.254	0.97 (0.86-1.11)	0.688
Entertainment						
<4 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥4 hrs/week	0.88 (0.79-0.98)	**0.025**	0.92 (0.81-1.05)	0.226	0.91 (0.82-1.01)	0.089

investigated similar issues was conducted in Northern Greece and showed that PA and BMI were negatively associated.[17] In a European study, the EPIC-PANACEA survey, which was conducted in 9 European countries, it was demonstrated that both PA at work and leisure-time physical activity were inversely correlated with BMI and waist circumference.[11] Accordingly, most international studies found an inverse relationship between PA and OB.[18] In fact, regular exercise on a permanent basis can regulate energy balance, body fat and body homeostasis.[19] A recent review that reported on the prevalence of OB and predisposing factors in Greece from the second World War until today concluded that both sedentary lifestyle and lack of sports and exercise practices contribute to excess body weight.[20] Walking in particular may reduce the risk of obesity, other cardiometabolic risk factors and cardiovascular disease, and specifically ischemic stroke.[21]

In the second part of our study we examined the relationship between PA patterns and the presence of cardiometabolic risk factors as reported in our population. Notably, prevalence of risk factors in our sample was found to be lower than those reported in similar Greek studies,[9,22] this possibly due to the screening methodology used to investigate the presence of these comorbidities (proxy, self-reported data) or to the relatively young age of the participants compared to other studies. In a similarly designed US study,[23] similar rates of T2DM and HCE were found but those of HTN were reported to be higher in comparison to our study.

In men, the risk of HCE and HTN decreased after

Table 4. Odds ratio of dyslipidemia, diabetes mellitus and hypertension by different physical activity patterns in men

	Hypercholesterolemia		Diabetes mellitus		Hypertension	
Predictor	**Odds Ratio (95%CI)**	**P**	**Odds Ratio (95%CI)**	**P**	**Odds Ratio (95%CI)**	**P**
Age group						
18-39	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
40-65	2.76 (2.14-3.56)	<0.001	2.46 (1.61-3.74)	<0.001	4.25 (2.93-6.17)	<0.001
>65	4.03 (2.79-5.84)	<0.001	9.62 (5.83-15.88)	<0.001	22.07 (14.38-33.87)	<0.001
Walking						
<2 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
2 – 3.9 hrs/week	1.18 (0.97-1.43)	0.100	1.02 (0.78-1.32)	0.544	1.08 (0.86-1.37)	0.509
4 – 6.9 hrs/week	1.14 (0.92-1.41)	0.220	0.88 (0.65-1.16)	0.236	1.08 (0.84-1.40)	0.534
≥7 hrs/week	0.91 (0.77-1.07)	0.250	0.79 (0.55-1.07)	0.092	0.98 (0.81-1.18)	0.808
Exercise						
<2 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
2 – 3.9 hrs/week	0.67 (0.42-1.08)	0.098	1.04 (0.54-1.99)	0.907	0.60 (0.32-1.11)	0.104
4 – 6.9 hrs/week	0.93 (0.62-1.41)	0.733	0.30 (0.10-0.96)	**0.042**	0.50 (0.28-1.00)	**0.049**
≥7 hrs/week	0.45 (0.23-0.90)	**0.023**	0.60 (0.22-1.65)	0.326	1.14 (0.64-2.05)	0.656
TV watching						
<16 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥16 hrs/week	1.20 (1.02-1.39)	**0.023**	1.17 (0.92-1.49)	0.194	1.36 (1.14-1.62)	**0.001**
Office work						
<14 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥14 hrs/week	1.55 (1.34-1.80)	**<0.001**	1.12 (0.87-1.44)	0.372	1.33 (1.11-1.59)	**0.002**
Entertainment						
<4 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥4 hrs/week	0.93 (0.80-1.07)	0.289	0.94 (0.75-1.18)	0.575	0.93 (0.79-1.10)	0.409

regular exercise for more than 7 hours per week and 4 hours per week, respectively, and increased with TV watching for more than 16 hours per week and office work for more 14 hours per week. Additionally, the risk of T2DM decreased after exercising for more than 4 hours per week. In women, frequent TV watching increased the risk of HTN and frequent office work decreased the risk of T2DM, while physical activity practices did not affect any of these cardiometabolic factors.

In the ATTICA study, a regional Greek study, physical activity was found to be inversely associated with the cumulative risk factors score of OB, HTN, HCE, and T2DM, in both genders, but not with each risk factor separately.[10]

Similarly, Athyros et al. reported that the prevalence of metabolic syndrome in Greek adults was high (23.6% in total; 24.2% for men and 23.6% for women) and the majority of the participants reported a sedentary lifestyle, with TV watching being their main entertainment activity (approximately 4 hours per day).[9]

A number of studies have reported that higher levels of PA, especially moderate-intensity exercise, are associated with significant reduction in risk of T2DM[24] and insulin resistance.[25] Williams showed that exercise intensity is inversely associated with the prevalence of HTN, HCE and T2DM.[26] The same author found, in another report, that fitter men had lower odds of becoming diabetic, hypercholesterolemic and hypertensive (86%, 67%, 62%, respectively).[27] Gill and Cooper presented data from six large-scale interventional trials and showed that adults with impaired glucose tolerance or at high risk of CVD had

Table 5. Odds ratio of dyslipidemia, diabetes mellitus and hypertension by different physical activity patterns in women

	Hypercholesterolemia		Diabetes mellitus		Hypertension	
Predictor	**Odds Ratio (95%CI)**	**P**	**Odds Ratio (95%CI)**	**P**	**Odds Ratio (95%CI)**	**P**
Age group						
18-39	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
40-65	2.40 (1.98-2.90)	**<0.001**	1.73 (1.29-2.33)	**<0.001**	3.27 (2.60-4.12)	**<0.001**
>65	8.15 (6.32-10.50)	**<0.001**	10.93 (7.83-15.25)	**<0.001**	27.63 (21.10-36.18)	<0.001
Walking						
<2 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
2 – 3.9 hrs/week	1.18 (0.96-1.46)	0.121	1.12 (0.81-1.54)	0.485	0.98 (0.77-1.24)	0.845
4 – 6.9 hrs/week	1.10 (0.88-1.39)	0.399	0.79 (0.54-1.16)	0.238	1.17 (0.91-1.50)	0.216
≥7 hrs/week	0.83 (0.68-1.02)	0.079	0.89 (0.66-1.19)	0.426	1.07 (0.87-1.32)	0.529
Exercise						
<2 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
2 – 3.9 hrs/week	0.82 (0.56-1.21)	0.316	0.46 (0.20-1.04)	0.062	0.64 (0.40-1.03)	0.069
4 – 6.9 hrs/week	0.61 (0.34-1.10)	0.103	0.87 (0.38-1.98)	0.739	0.83 (0.46-1.50)	0.535
≥7 hrs/week	1.17 (0.61-2.26)	0.636	1.66 (0.67-4.11)	0.277	0.60 (0.22-1.64)	0.320
TV watching						
<16 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥16 hrs/week	1.13 (0.95-1.35)	0.159	1.10 (0.85-1.42)	0.465	1.33 (1.11-1.60)	**0.002**
Office work						
<14 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥14 hrs/week	0.95 (0.76-1.19)	0.665	0.64 (0.42-0.97)	**0.034**	0.81 (0.63-1.06)	0.121
Entertainment						
<4 hrs/week	1.00 (Ref.)		1.00 (Ref.)		1.00 (Ref.)	
≥4 hrs/week	0.96 (0.79-1.16)	0.665	0.89 (0.66-1.21)	0.465	0.89 (0.72-1.10)	0.268

a decreased risk of diabetes upon moderate increase of PA by approximately 150 minutes per week, and the effect was greater if accompanied by weight loss.[28] The reverse association, e.g. people with metabolic risk factors tend to exercise more, could also occur, but it seems less probable.

A recent review by Katzmarzyk and Lear demonstrated that physical activity had only a modest effect on chronic disease risk factors in obese individuals.[29] Thus, after introducing exercise, six out of ten research groups reported a statistically significant reduction in diastolic blood pressure, eight out of ten in systolic blood pressure and only two out of nine found a reduction in fasting insulin. Most of the studies showed improvements in blood lipid levels (LDL-C, HDL-C, TGs).[29]

The correlation of walking with the risk of metabolic comorbidities was less evident. More than 7 hours of walking per week were needed to establish a lower risk of HCE.

As far as sedentary behaviours are concerned, in our study, both frequent TV watching and office work increased the risk of HCE and HTN in men, while in women, TV watching increased only the risk of HTN. Healy et al.[30] indicated a detrimental association of time spent in TV watching with waist circumference, systolic blood pressure and 2-h plasma glucose in both men and women, and with fasting plasma glucose, triglycerides and HDL-C only in women.[30] Recently, Thorp et al. provided evidence that time spent on TV watching was detrimentally associated with all cardiometabolic risk biomarkers.[31]

TV watching leads to harmful habits such as passive snacking and lust for sugar-sweetened soft drinks and energy-dense foods.[32] It causes lower metabolic rate in comparison with other sedentary activities like sewing, playing board games, driving a car, reading and writing.[33] Finally, the relation between TV watching and metabolic diseases could be partly attributed to the psychological stress induced by TV, which enhances insulin resistance, sympathetic system activation, visceral adiposity and metabolic syndrome.

Notably, the aforementioned associations between physical activity, sedentary lifestyle patterns and cardiometabolic risk factors were observed almost exclusively in the male gender. This specific finding has also been highlighted in some recent epidemiological studies and principally concerns the negative relationship between TV watching, office work and cardiometabolic parameters.[34,35] It is possible that molecular metabolic pathways active in men during physical activity are more closely related to cardiometabolic risk factors or it may simply be the result of over-reporting of PA (or underreporting of sedentary behaviours) by the women.[36] One finding that needs to be underlined is the differentiated gender effect on cardiometabolic factors that was produced by office work. In men, frequent office work increased the risk of HCE and HTN, while in women it was associated with decreased risk of T2DM. It is possible that office work in women is expressed via higher activity levels in contrast to men, who tend to be more sedentary in this setting.

Some limitations of our study have to be mentioned. Anthropometric measurements in the study population were performed by adolescents 13-19 years old who were trained by school instructors. Although the adolescents were thoroughly trained for this purpose, this is not a validated survey method. Also, the presence of cardiometabolic comorbidities was based on self-report and could not be verified. However, the major strength of this study is that it is the first large-scale survey ever conducted across the country, which allows the evaluation of the association of OB and its comorbidities with PA and sedentary lifestyle, albeit in a non-representative manner.

In conclusion, the present study is the first report of a Greek population-based study to show that walking activity in adults, and particularly in men, was significantly associated with low risk for obesity status, while frequent exercise practices and lower sedentary behaviour were associated with reduced risk for cardiometabolic factors, mainly hypercholesterolemia and hypertension. Our data call attention to the need for the implementation of effective interventions that should combine: a) restrictions of sedentary behaviours, such as staying indoors, TV watching, playing computer games or motorized transport, and b) increase of outdoor activities such as sports, walking, bicycling, climbing stairs and entertainment activities. The study of exercise and leisure activity patterns and their determinants could provide information on specific population subgroups that are at risk for developing OB and associated comorbidities. Thus, public health programs should take these factors into consideration when planning strategies for the prevention and management of OB and its comorbidities.

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