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Gender heterogeneity in the association between lifestyles and non-fatal acute myocardial infarction

Andreia Oliveira*, Henrique Barros and Carla Lopes
Department of Hygiene and Epidemiology and Cardiovascular Research & Development Unit, University of Porto Medical School, Alameda Prof. Hernâni Monteiro 4200-319 Porto, Portugal

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Abstract

Objective: To evaluate the modification effect of sex in the association between lifestyles and acute myocardial infarction (AMI).
Design: Population-based case–control study. Trained interviewers collected information using a standard structured questionnaire. Associations were estimated using unconditional logistic regression. The effect modification by sex was evaluated in the regression models, testing interaction terms between lifestyles and sex.
Setting: Porto, Portugal.
Subjects: Portuguese Caucasian adults, aged ≥18 years. Cases were patients consecutively admitted with an incident AMI during 1999–2003 (*n* 918) and controls were a representative sample of non-institutionalized inhabitants of Porto with no evidence of previous clinical or silent infarction (*n* 2316).
Results: Cigarette smoking was positively associated with AMI in both men and women (smokers >15 cigarettes/d *v.* never smokers: OR = 9·11, 95 % CI 4·83, 17·20 for women; OR = 3·92, 95 % CI 2·75, 5·58 for men; interaction term *P* value = 0·001). A significant protective effect of moderate alcohol intake on AMI occurrence was found in women (0·1–15·0 g/d *v.* non-drinkers: OR = 0·48, 95 % CI 0·31, 0·74), but not in men. Fruit and vegetable intake, vitamin and mineral supplement use and leisure-time physical activity practice were found to decrease AMI risk, with similar effects between sexes.
Conclusions: A strong positive association between smoking and AMI was found in women. Also, a protective effect of moderate alcohol intake was only found among females. Fruit and vegetable intake, vitamin and mineral supplement use and leisure-time physical activity practice were found to decrease AMI risk in both sexes.

Keywords
Myocardial infarction
Lifestyles
Case–control study
Sex differences

CHD is the result of a complex interplay between genetic features and social and behavioural exposures[1,2], but differences across populations appear to be more related with lifestyles than with genetic make-up[3,4]. The modifiable pattern and the considerably high population-attributable risk of lifestyles to the development of CHD[5] underline the importance of still studying these associations in populations with different ranges of exposures.

Smoking is considered the most important risk factor for CHD, particularly among young adults[6], but the relative importance between sexes is not very clear. Studies have pointed out the particularly harmful effect of smoking among women[7,8], but also some studies describe it as a major hazard for acute myocardial infarction (AMI), regardless of sex[9,10].

A large number of observational studies have shown a J-shaped relationship between moderate alcohol consumption and CHD[11], but less information is available about the effect of higher levels of consumption. In populations with high levels of alcohol intake, such as those of the Eastern European countries, the effect of alcohol has been frequently studied in relation to total mortality[12] but not the occurrence of disease. Portugal has a considerably wide range of alcohol exposure and the highest levels of alcohol consumption among European countries[13], particularly among men, which improves the study of this association in this specific population.

Fruit and vegetable intake represents a marker of healthy dietary intake and has been described as protective for some CVD[14]. The current recommended intake of 5 or more portions of fruit and vegetables daily is widespread throughout the world, but the evaluation of this specific cut-off point in the reduction of disease risk is frequently neglected, as are sex-related differences.

Several studies have studied the effect of total physical activity on the prevention of CHD[15,16], but few focus

*Corresponding author: Email acmatos@med.up.pt

specifically on clarifying the differences between total and leisure-time physical expenditure on this association.

Overall, the profile of risk factors for CHD appears to be somewhat different between sexes[17,18], but the differences are quantitatively limited and inconsistent across studies. Most studies do not evaluate by appropriate statistical methods differences by sex nor study a broad range of lifestyles on AMI risk within the same population. The modifiable profile of lifestyles together with a better understanding of these associations enhances the development of effective targeted public health interventions to prevent myocardial infarction events.

The aim of the present study was to evaluate the modification effect of sex in the association between lifestyles and AMI.

Methods

Study design and sample selection

A population-based case–control study was conducted during 1999–2003 in Porto, a large urban centre in the north-west of Portugal with almost 300 000 inhabitants. All participants were Portuguese Caucasian adults, aged ≥18 years.

Cases were patients consecutively admitted to the Cardiology Department of the four hospitals providing acute coronary care in Porto, who survived beyond the fourth day after a first diagnosis of an AMI. The diagnosis was established considering infarction with and without ST segment elevation and according to standard criteria[19].

Controls were identified as part of a health and nutrition survey of a representative sample of the non-institutionalized adult population of Porto (the EPIPorto study), selected by random digit dialling. Refusals were not substituted and the participation proportion was estimated as 70 % (66·3 % in women and 74·7 % in men)[20].

A rapid evaluation of cognitive function was done using the Mini-Mental State Examination test (MMSE)[21] in participants older than 64 years.

During the study period, 1248 patients with an incident AMI were identified, but some were excluded because they were unable to collaborate (*n* 67), died (*n* 37), did not complete the interview (*n* 85), or scored less than 24 in the MMSE (*n* 138). Only three refused to participate.

Out of 2485 community participants, 114 (4·6 %) were excluded due to previous clinical or silent infarction according to self-reported data and/or a 12-lead electrocardiogram, nine due to incomplete information or physical disability, and forty-six because they scored less than 24 in the MMSE test. The final sample included 3234 subjects: 918 cases (222 women and 696 men) and 2316 controls (1449 women and 867 men).

The Ethics Committees of the four participating hospitals approved the study protocol and every participant gave written informed consent.

Data collection and definition of variables

Data on cases and controls were collected by the same set of trained interviewers, using a standard structured questionnaire that included information on social, demographic, anthropometric and behavioural characteristics.

Patients were interviewed during the hospital stay, after clinical stabilization, and controls were invited to visit the department to be evaluated by face-to-face interviews.

Smoking

Smoking habits were self-reported and participants were classified, based on the WHO categories[22], into never smokers, current daily smokers (at least one cigarette a day), current occasional smokers (less than one cigarette a day) and ex-smokers (quit smoking for least 6 months). The cut-off point for exposure categories was set at 15 cigarettes/d instead of 20 cigarettes/d (a pack of cigarettes) to minimize digit preference bias.

Dietary intake and alcohol consumption

Dietary intake and alcohol consumption were estimated by a validated eighty-two-item semi-quantitative FFQ covering the previous year[23,24]. Information on nutrient intake was obtained using the software Food Processor Plus® (ESHA Research, Salem, OR, USA), which has been adapted to Portuguese food and national traditional dishes.

Different classes of alcohol consumption were defined by the cut-off points 15·0 and 30·0 g/d for women and 30·0 and 60·0 g/d for men, according to the guidelines of the American Heart Association[25]. For women and men respectively, participants with an alcohol intake at or below 15·0 and 30·0 g/d were considered moderate alcohol drinkers and those with intake levels above 30·0 and 60·0 g/d were considered as excessive alcohol drinkers.

For total energy intake, participants were classified according to the quartile distribution in controls.

Fruit and vegetable intake was stratified into <5 and ≥5 portions/d, according to the current recommendations of 400 g of daily consumption. Only fresh fruit, natural fruit juice, fresh vegetables and vegetable soup were considered for the definition of the fruit and vegetable intake variable.

Vitamin and mineral supplements

Vitamin and mineral supplement use referred to chronic consumption (more than two consecutive weeks) during the year before the interview.

Physical activity

Total physical activity was quantified after a detailed recall of professional, domestic and leisure-time physical activities and was expressed as metabolic equivalents[26]. Participants were classified according to the quartile distribution of physical activity in controls. Leisure-time physical activity practice was also asked and defined as a regular practice of any leisure-time physical activity, including walking.

Medical history

A positive family history of AMI was considered when at least one first-degree relative had had an AMI or had suddenly died by unknown cause, regardless of the age when the event occurred.

Anthropometrics

Anthropometric variables were obtained with subjects fasting, in light clothing and barefoot. Body height was measured to the nearest 0·1 kilogram using a digital scale (SECA®) and height was measured to the nearest centimetre using a wall stadiometer (SECA®). Waist circumference was measured to the nearest centimetre, midway between the lower limit of the rib cage and the iliac crest, using a flexible and non-distensible tape. The waist circumference was categorized into <88 cm and ≥88 cm for women and <102 cm and ≥102 cm for men, according to the Adult Treatment Panel (ATP III) guidelines.

Statistical analysis

The χ^2 was used to compare categorical variables and the Mann–Whitney test was computed to compare continuous variables between two independent samples. The distribution of variables was tested by the Kolmogorov–Smirnov test.

The associations between lifestyles and AMI were estimated by crude and adjusted odds ratios and respective 95 % confidence intervals, using unconditional logistic regression models. Adjustments were made for age and education (continuous variables) and a final model was fitted adjusting for social, behavioural and clinical characteristics which in the crude analysis were significantly associated with AMI, i.e. age, education (as continuous variables), waist circumference, alcohol consumption, total energy intake, fruit and vegetable intake, vitamin and supplement use, leisure-time physical activity, smoking and family history of infarction (as categorical variables). For women, the final model was also adjusted for parity and menopause with and without hormone replacement therapy.

The effect modification by sex on AMI risk was evaluated in the regression models, testing interaction terms between lifestyles and sex.

Data were analysed using the STATA® statistical software package version 9·0 (StataCorp, College Station, TX, USA).

Results

Female cases of AMI were significantly older, less educated and presented higher median BMI values compared with controls (Table 1). Female cases were also more frequently current smokers, excessive alcohol drinkers (>30 g alcohol/d) and reported more often a fruit and vegetable intake of <5 portions/d, no use of vitamin and mineral supplements in the past year and not to practise regular leisure-time physical activities. Compared with controls, female cases were more frequently in the lower quartiles of energy intake and total physical activity. Male cases were also significantly less educated, had higher median BMI values and were more often current smokers and excessive alcohol drinkers (>60 g alcohol/d) compared with controls. Male cases were more frequently in the higher quartiles of energy intake and total physical activity, and about 80 % reported not practising regular leisure-time physical activities compared with about 59 % of controls. Also, cases of both sexes more often reported a family history of AMI than controls.

The crude and adjusted odds ratio estimates for the association between lifestyles and AMI are presented in Table 2 for women and in Table 3 for men.

Cigarette smoking was strongly and positively associated with AMI occurrence in both sexes. Smokers of >15 cigarettes/d had increased risk estimates compared with never smokers (OR = 9·11, 95 % CI 4·83, 17·20 for women; OR = 3·92, 95 % CI 2·75, 5·58 for men; interaction term P value <0·001). The risk estimates for ex-smokers were similar to those for never smokers.

A significant interaction effect between sex and alcohol intake on AMI risk was found (interaction term P value = 0·037). In the final model, after adjustment for a range of potential confounders (social, clinical and behavioural), women had a significant protective effect from moderate alcohol intake (≤15 g/d *v.* non-drinkers: OR = 0·48, 95 % CI 0·31, 0·74), but among men no significant associations were observed between alcohol intake and the occurrence of the disease.

For both sexes, the consumption of ≥5 portions of fruit and vegetable daily was inversely associated with AMI (OR = 0·64, 95 % CI 0·44, 0·95 for women and OR = 0·86, 95 % CI 0·65, 1·12 for men; interaction term P value = 0·660).

A significant inverse association was also found between vitamin and mineral supplement use and AMI occurrence for both women and men (OR = 0·49, 95 % CI 0·31, 0·78 and OR = 0·51, 95 % CI 0·34, 0·79 respectively; interaction term P value = 0·523).

Total physical activity and particularly leisure-time physical activity (OR = 0·45, 95 % CI 0·27, 0·74 for women and OR = 0·53, 95 % CI 0·40, 0·70 for men; interaction term P value = 0·468) were found to have a protective effect on AMI occurrence in both sexes.

Discussion

Smoking was positively associated with AMI in both sexes, but female current cigarette smokers presented

Table 1 Characteristics of acute myocardial infarction cases and controls by sex: adults aged ≥18 years, Porto, Portugal

	Women*				Men†			
	Cases (*n* 222)		Controls (*n* 1449)		Cases (*n* 696)		Controls (*n* 867)	
	Median	P25–P75	Median	P25–P75	Median	P25–P75	Median	P25–P75
Education (years)	4	3–6	7	4–14	4	4–9	9	4–14
BMI (kg/m^2)	27·9	24·8–30·9	26·4	23·5–30·1	26·4	24·4–28·5	25·9	23·6–28·0
	n	%	*n*	%	*n*	%	*n*	%
Age (years)								
18–40	16	7·2	330	22·8	139	20·0	194	22·4
41–50	39	17·6	339	23·4	233	33·5	196	22·6
51–64	79	35·6	453	31·3	219	31·5	256	29·5
≥65	88	39·6	327	22·6	105	15·1	221	25·5
Waist circumference (cm)‡								
<88 (W); <102 (M)	62	27·9	836	57·7	506	72·7	710	81·9
≥88 (W); ≥102 (M)	160	72·1	613	42·3	190	27·3	157	18·1
Family history of infarction (yes)	89	40·1	359	24·8	209	30·0	167	19·3
Tobacco smoking								
Never smokers	164	74·2	1035	71·6	105	15·1	250	28·8
Ex-smokers	11	5·0	153	10·6	160	23·0	312	36·0
Smokers 1–15 cigarettes/d	13	5·9	155	10·7	56	8·1	119	13·7
Smokers >15 cigarettes/d	33	14·9	102	7·1	374	53·8	186	21·5
Alcohol consumption (g/d)§								
0	124	56·4	672	46·6	74	10·8	121	14·0
0·1–15·0 (W); 0·1–30·0 (M)	50	22·7	543	37·7	209	30·4	392	45·4
15·1–30·0 (W); 30·1–60·0 (M)	35	15·9	176	12·2	209	30·4	249	28·9
>30·0 (W); >60·0 (M)	11	5·0	50	3·5	196	28·5	101	11·7
Total energy intake quartile (kcal/d)‖								
1st quartile	70	31·8	360	25·0	163	23·7	216	25·0
2nd quartile	53	24·1	361	25·0	143	20·8	216	25·0
3rd quartile	39	17·7	360	25·0	154	22·4	215	24·9
4th quartile	58	26·4	360	25·0	228	33·1	216	25·0
Fruit and vegetable intake (portions/d)								
<5	138	62·7	632	43·9	463	67·3	439	50·9
≥5	82	37·3	809	56·1	225	32·7	424	49·1
Vitamin and mineral supplement use								
No	191	86·0	1009	69·7	652	93·8	715	82·7
Yes	31	14·0	438	30·3	43	6·2	150	17·3
Total physical activity quartile (MET × h/d)¶								
1st quartile	91	41·0	363	25·1	222	32·0	207	24·0
2nd quartile	55	24·8	357	24·7	86	12·4	224	26·0
3rd quartile	39	17·6	364	25·2	124	17·9	215	25·0
4th quartile	37	16·7	360	25·0	262	37·8	215	25·0
Leisure-time physical activity practice								
No	194	87·4	993	68·6	550	79·1	509	58·7
Yes	28	12·6	455	31·4	145	20·9	358	41·3

P25–P75, interquartile range; W, women; M, men; MET, metabolic equivalent.
*$P < 0·001$ for all variables, except for BMI ($P = 0·001$) and total energy intake ($P = 0·049$).
†$P < 0·001$ for all variables, except for age ($P = 0·002$), BMI ($P = 0·012$), waist circumference ($P = 0·064$) and total energy intake ($P = 0·004$).
‡Cut-off points defined separately by sex (88 cm for women and 102 cm for men).
§Classes defined separately by sex (15·0 and 30·0 g alcohol/d for women, 30·0 and 60·0 g alcohol/d for men).
‖Quartiles defined separately by sex, according to controls' distribution (kcal/d, for 1st, 2nd, 3rd and 4th quartile respectively: <1747·0, 1747·0–2050·1, 2050·2–2369·8 and >2369·8 for women; <1989·0, 1989·0–2315·4, 2315·5–2724·1 and >2724·1 for men; to convert to kJ, multiply kcal by 4·184).
¶Quartiles defined separately by sex, according to controls' distribution (MET × h/day, for 1st, 2nd, 3rd and 4th quartile respectively: <33·0, 33·0–34·5, 34·6–38·2 and >38·2 for women; <32·6, 32·6–34·2, 34·3–39·3 and >39·3 for men).

stronger risk estimates for the occurrence of the disease. It is well established that smoking is an important risk factor for CHD, regardless of age and sex[5], with increasing risks according to the number of cigarettes smoked. Also, in the present study, smokers of ≥15 cigarettes/d had approximately a threefold increased of AMI risk than smokers of <15 cigarettes/d, both compared with never smokers. In the Framingham Study, for each 10 cigarettes smoked daily, the risk of CVD increased by 18 % in men and 31 % in women of all ages[27]. Although smoking is considered a major hazard for AMI in both sexes, some studies have pointed out the particularly harmful effect of the relative oestrogen deficiency that female smokers appear to have[28] and an interaction between oral contraceptives and smoking has also been discussed[29]. However, other studies support that in young adults there is no interaction between sex and smoking on AMI risk[9,10,30]. The present study also found a similar risk for AMI between ex-smokers and never smokers, supporting the beneficial effect of smoking cessation in both sexes.

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Table 2 Association between lifestyles and acute myocardial infarction in women: adults aged ≥18 years, Porto, Portugal

	Crude		Adjusted*		Adjusted†	
	OR	95 % CI	OR	95 % CI	OR	95 % CI
Tobacco smoking						
Never smokers	1·00‡		1·00‡		1·00‡	
Ex-smokers	0·45	0·24, 0·86	1·12	0·57, 2·20	1·32	0·60, 2·93
Smokers 1–15 cigarettes/d	0·53	0·29, 0·45	1·71	0·88, 3·31	2·33	1·10, 4·94
Smokers >15 cigarettes/d	2·04	1·33, 3·12	7·15	4·19, 12·20	9·11	4·83, 17·20
Alcohol consumption (g/d)						
0	1·00‡		1·00‡		1·00‡	
0·1–15·0	0·50	0·35, 0·71	0·53	0·37, 0·76	0·48	0·31, 0·74
15·1–30·0	1·08	0·72, 1·62	0·83	0·54, 1·28	0·73	0·44, 1·21
>30·0	1·19	0·60, 2·35	0·99	0·49, 2·01	0·98	0·45, 2·16
Total energy intake quartile (kcal/d)						
<1747·0	1·00‡		1·00‡		1·00‡	
1747·0–2050·1	0·76	0·51, 1·11	0·81	0·54, 1·20	0·72	0·44, 1·18
2050·2–2369·8	0·56	0·37, 0·85	0·63	0·41, 0·97	0·66	0·39, 1·13
>2369·8	0·83	0·57, 1·21	1·15	0·77, 1·71	1·43	0·85, 2·41
Fruit and vegetable intake (portions/d)						
<5	1·00‡		1·00‡		1·00‡	
≥5	0·46	0·35, 0·62	0·57	0·42, 0·77	0·64	0·44, 0·95
Vitamin and mineral supplement use						
No	1·00‡		1·00‡		1·00‡	
Yes	0·37	0·25, 0·56	0·40	0·27, 0·60	0·49	0·31, 0·78
Total physical activity quartile (MET × h/d)						
<33·0	1·00‡		1·00‡		1·00‡	
33·0–34·5	0·62	0·43, 0·88	0·70	0·48, 1·02	0·76	0·47, 1·22
34·6–38·2	0·43	0·29, 0·64	0·57	0·37, 0·86	0·64	0·39, 1·06
>38·2	0·41	0·27, 0·62	0·51	0·32, 0·81	0·55	0·31, 0·96
Leisure-time physical activity practice						
No	1·00‡		1·00‡		1·00‡	
Yes	0·32	0·21, 0·48	0·40	0·26, 0·61	0·45	0·27, 0·74

MET, metabolic equivalents.
*Odds ratio adjusted for age and education.
†Odds ratio adjusted for age, education, waist circumference, smoking, alcohol consumption, total energy intake, fruit and vegetable intake, vitamin and mineral supplement use, leisure-time physical activity, family history of infarction, parity and menopause with and without hormone replacement therapy.
‡Reference class.

The Albany and Framingham combined study[31] showed that one year after individuals quit smoking, the risk of CHD decreases by half and, at term, ex-smokers and never smokers face similar risks.

A statistically significant protective effect of moderate alcohol intake on AMI was found only among women. This sex difference (interaction P value = 0·037) is probably related to the distribution of exposure in the sample studied, in which women were more frequently non-drinkers and moderate alcohol drinkers than men. Among the latter, a considerable proportion had excessive alcohol habits; however, the positive association found between excessive alcohol habits and the occurrence of disease did not remain statistically significant after the final model adjustments. The use of different cut-off points to define moderate and excessive alcohol habits within sexes, as suggested by the American Heart Association guidelines, may, to some extent, limit straight comparisons within sexes.

The advisory statement of the American Heart Association Nutrition Committee points out the increased CHD risk with excessive alcohol consumption and the protective effect of moderate consumption[32], which seems to be independent of the type of alcoholic beverage[33]. This beneficial effect could result from an increase of HDL-cholesterol, antithrombotic actions, a reduced insulin resistance, a postprandial growth modulation of smooth muscular cells[34,35] or through anti-inflammatory properties[36].

The inverse association of fruit and vegetable intake with AMI found in the present study is consistent with a recent meta-analysis based on cohort studies[14]. In fact, accumulating evidence addressing this issue led to the current recommendation of a fruit and vegetable intake of ≥400 g/d or ≥5 portions/d based primarily on the belief that the beneficial combinations of micronutrients, antioxidants and fibre present in these foods may reduce the risk of CVD and certain cancers. Despite this inverse association found, the risk estimates were similar between sexes.

In the present study, after multivariate analysis, vitamin and mineral supplement use was found to have a protective effect on AMI occurrence, even after removing the effect of fruit and vegetable intake (included as a covariable in the final regression models). Accumulating observational evidence indicates that the use of supplements, such as antioxidant vitamins, could to some extent prevent CVD[37]. Despite the plausibility of a protective

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Table 3 Association between lifestyles and acute myocardial infarction in men: adults aged ≥18 years, Porto, Portugal

	Crude		Adjusted*		Adjusted†	
	OR	95 % CI	OR	95 % CI	OR	95 % CI
Tobacco smoking						
Never smokers	1·00‡		1·00‡		1·00‡	
Ex-smokers	1·22	0·91, 1·64	1·16	0·85, 1·59	1·08	0·75, 1·56
Smokers 1–15 cigarettes/d	1·12	0·76, 1·66	1·26	0·83, 1·90	1·42	0·89, 2·29
Smokers >15 cigarettes/d	4·79	3·59, 6·38	4·49	3·30, 6·09	3·92	2·75, 5·58
Alcohol consumption (g/d)						
0	1·00‡		1·00‡		1·00‡	
0·1–30·0	0·87	0·62, 1·22	0·90	0·63, 1·27	0·78	0·52, 1·17
30·1–60·0	1·37	0·97, 1·93	1·17	0·82, 1·67	0·83	0·54, 1·28
>60·0	3·17	2·18, 4·62	2·20‡	1·48, 3·27	1·50	0·92, 2·46
Total energy intake quartile (kcal/d)						
<1989·0	1·00‡		1·00‡		1·00‡	
1989·0–2315·4	0·88	0·65, 1·18	0·87	0·64, 1·18	0·88	0·60, 1·27
2315·5–2724·1	0·95	0·71, 1·27	0·82	0·60, 1·12	0·79	0·54, 1·17
>2724·1	1·40	1·06, 1·84	1·04	0·77, 1·41	0·90	0·60, 1·34
Fruit and vegetable intake (portions/d)						
<5	1·00‡		1·00‡		1·00‡	
≥5	0·50	0·41, 0·62	0·61	0·49, 0·76	0·86	0·65, 1·12
Vitamin and mineral supplement use						
No	1·00‡		1·00‡		1·00‡	
Yes	0·31	0·22, 0·45	0·42	0·29, 0·61	0·51	0·34, 0·79
Total physical activity quartile (MET × h/d)						
<32·6	1·00‡		1·00‡		1·00‡	
32·6–34·2	0·36	0·26, 0·49	0·40	0·29, 0·56	0·43	0·29, 0·63
34·3–39·3	0·54	0·40, 0·72	0·49	0·36, 0·67	0·51	0·35, 0·73
>39·3	1·14	0·88, 1·48	0·77	0·57, 1·03	0·81	0·57, 1·16
Leisure-time physical activity practice						
No	1·00‡		1·00‡		1·00‡	
Yes	0·38	0·30, 0·47	0·46	0·37, 0·59	0·53	0·40, 0·70

MET, metabolic equivalents.
*Odds ratio adjusted for age and education.
†Odds ratio adjusted for age, education, waist circumference, smoking, alcohol consumption, total energy intake, fruit and vegetable intake, vitamin and mineral supplement use, leisure-time physical activity and family history of infarction.
‡Reference class.

role of vitamin supplements regarding chronic diseases based on their inhibition effects of LDL-cholesterol oxidation, epidemiological findings remain controversial, since randomized clinical trials do not support this beneficial effect[38,39]. The considerable amount of uncontrolled and uncontrollable confounding inherent to case–control and cohort studies, such as the simple correlation of antioxidant vitamin intake from supplements and food and unmeasured or unknown non-dietary factors which protect against CHD[40], could somewhat explain this beneficial effect.

Physical activity is a well-documented protective factor for CHD[16]. It influences blood pressure levels, insulin resistance, BMI and serum lipid levels[41,42], provides a better haemostatic profile[43] and stimulates cytokines production[44]. In fact, in the present study a beneficial effect of regular leisure-time physical activity practice was clearly revealed, similarly for both sexes. Concerning total physical activity, only subjects with moderate levels of practice seemed to be protected, probably because the upper quartile, particularly in men, is reflecting heavy professional physical activities, which have been described as not having the supposed protective effects[45]. Therefore, it is believed that the benefits of physical activity are mostly focused on leisure-time physical activity rather than work-related energy expenditure.

Study strengths and limitations

Sample selection and information recall biases are known sources of error in case–control studies. To minimize it as much as possible, cases of AMI were approached during their in-hospital stay and only incident cases were considered, which should reduce potential bias resulting from behavioural modifications after the acute event. Furthermore, these cases constituted a representative sample of non-fatal AMI patients, as all diagnosed cases in Portugal are admitted to public hospitals. Given the almost universal participation of cases, any effect on risk estimates would be almost exclusively attributable to the compromise in the impaired representativeness of the control group. The relatively high participation proportion among controls and the fact that different characteristics of participants and non-participants, who were older and more frequently women, had little or no impact on the direction or magnitude of myocardial infarction risk estimates, as previous described[46], reduced the probability of a non-response bias.

The potential confounding effect of several covariates was allowed for in the statistical analysis. Clinical variables such as dyslipidaemia, hypertension and diabetes, known risk factors for AMI, were not presented in the final model, because they could be considered potential intermediate steps in the causal chain between behavioural risk factors and myocardial infarction. Even so, an additional model was tested with adjustment for dyslipidaemia, hypertension and diabetes, but the magnitude and significance of the estimates did not change.

Although the associations between behavioural risk factors and AMI have been investigated in depth in many different studies, most of them do not evaluate a broad range of lifestyles within the same population. Moreover, most of them do not study properly differences by sex, which limits comparisons with our study. A recent case–control study stated that major risk factors for AMI in fact differ between men and women[46] and most authors agree that the different risk factor profiles may account for much of the sex differences in mortality[47]. However, in the present study a gender effect on AMI risk was found only for smoking and alcohol intake. Overall, lifestyles have a strong and important independent effect on AMI occurrence. Given the potential modifiable pattern of lifestyles, primary preventive efforts hold much promise and enhance the importance of sustained and targeted public health interventions.

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