Public Health Nutrition: 11(8), 841–848 doi:10.1017/S1368980007001309

Dietary intake and different types of physical activity: full-day energy expenditure, occupational and leisure-time

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Submitted 21 December 2006: Accepted 16 September 2007: First published online 6 December 2007

Abstract

Objective: To describe the relationship between dietary intake and different levels and types of physical activity (PA).
Design: Cross-sectional evaluation of the EPIPorto study. Energy expenditure (metabolic energy equivalent tasks) and dietary intake during the past year were assessed using a PA questionnaire and a semi-quantitative food-frequency questionnaire, respectively.
Setting: Representative sample of adults in Porto, Portugal.
Subjects: Data were analysed for 2404 Portuguese Caucasian adults, aged between 18 and 92 years.
Results: For total PA, males who were active had significantly higher mean intake of energy (10·76 (2570·7) vs. 9·78 (2336·9) MJ/d (kcal/d), $P < 0·001$) and lower level of protein consumption (16·9 vs. 17·6 % of energy, $P < 0·001$) compared with sedentary males. In males, the association between total PA and energy intake remained after adjustment for age, education and body mass index. Similar results were observed when occupational activity was analysed. Concerning the energy expended in leisure time, in both genders, after adjustment for the previously described variables, a significant positive association was found between PA and intake of vitamin C (g/d): $\beta = 0·12$, 99 % confidence interval (CI) 0·02, 0·21 for females and $\beta = 0·13$, 99 % CI 0·03, 0·22 for males. Leisure-time activity in females was also positively associated with intakes of fibre, vitamin E, folate, calcium and magnesium, and negatively associated with saturated fat.
Conclusions: Higher levels of PA in leisure time were associated with higher intakes of micronutrients and lower intakes of saturated fat, particularly in females. For total and occupational PA, similar nutrient intake was observed between active and sedentary individuals.

Keywords
Dietary intake
Physical activity
Lifestyle

Among identified cardiovascular risk factors[1], physical inactivity and inappropriate dietary habits[2,3] have been described as major modifiable behaviours associated with poor health. Sedentary behaviour combined with an unhealthy diet is responsible for a large proportion of deaths and it has been hypothesised that changes in nutrition and physical activity (PA) patterns could reverse this situation[4]. The World Health Assembly of 2004 proposed a Global Strategy on Diet, Physical Activity and Health, highlighting the importance of the possible additive or synergistic effects of these factors in the design of health promotion interventions[3].

A better understanding of the relationship between PA and diet could enhance efforts to improve health outcomes for which both diet and sedentary behaviour are risk factors[5]. The importance of this relationship is underlined as part of the 10 general points, highlighted by Prentice *et al.*[4], concerning the need to explore the association between nutrition and PA and their relationship with chronic disease.

A high prevalence of obesity (26·1 % in females and 13·9 % in males) has already been described in the present study's population[6]. This prevalence is, in part, the result of an imbalance between regular PA and healthy dietary choices, leading to the hypothesis that changes in nutrition and PA patterns could reverse the obesity epidemic[4]. Some studies[7–10] have suggested that good or poor dietary practices and PA levels 'cluster' within individuals, but is not yet clear what type and intensity of activity is associated with dietary choices. As PA has been defined[11] as all movements in everyday life, including work, recreation, exercise and sporting activities, it seems relevant to investigate whether there is a differential effect between the type of PA and dietary intake.

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https://doi.org/10.1017/S1368980007001309 Published online by Cambridge University Press

Thus the aim of the present study was to describe the relationship between dietary intake and different levels of PA activity, i.e. full-day, occupational and leisure-time energy expenditure, among adults in Porto, Portugal.

Methods

Subjects

As part of a cross-sectional evaluation in the EpiPorto study, Portuguese Caucasian adults aged 18–92 years, living in Porto, were assessed. As described previously[12], participants were recruited by random digit dialling using households as the sampling unit. Once a household was selected, all residents were identified by age and sex, and one resident (aged more than 17 years) was randomly selected as the respondent, without allowing a replacement if there was a refusal. A participation rate of 70 % was achieved. Out of 2489 participants, 85 were excluded because 29 had incomplete information and 56 scored less than 24 in the Mini-Mental State Examination, a tool used for the rapid evaluation of cognitive impairment in individuals over 64 years of age[13]. The final sample included 2404 subjects (61·7 % females and 38·3 % males) with complete information on PA and food consumption.

Data collection

Information was collected by trained interviewers using a structured questionnaire which comprised questions on social, demographic, personal and family medical history, and behavioural characteristics (diet, PA, smoking and alcohol intake). Education was recorded as completed years of schooling. Smoking status was self-reported, and individuals were classified according to whether they were current smokers (including daily and occasional smokers) or not. Anthropometric data were obtained with subjects in light clothing and barefoot, after they had fasted overnight. Body weight was measured to the nearest 0·1 kg using a digital scale and height was measured to the nearest centimetre using a wall stadiometer; then body mass index (BMI, kg/m^2) was calculated by dividing the weight (in kg) by the square of height (in m). Waist circumference (WC) was measured to the nearest centimetre with a flexible and non-stretchable tape, avoiding exertion of pressure on the tissues and with the subject standing; WC was measured midway between the lower limit of the rib cage and the iliac crest.

Dietary assessment

Dietary intake during the previous year was estimated based on a validated semi-quantitative food-frequency questionnaire (FFQ), developed at the Department of Hygiene and Epidemiology, University of Porto Medical School[14,15]. The questionnaire comprised 82 food item and beverage categories and a frequency section with nine possible responses, ranging from never to six or more times per day. Participants were asked to indicate the average frequency of consumption, as well as the portion size based on a photograph manual with three portion sizes (small, medium, large) for each food item. Any foods that were not included in the FFQ food list but eaten regularly (once a week or more frequently) were listed in an open section. Nutrient intake was obtained from consumption frequency and portion size data using the software Food Processor Plus® (ESHA Research), based on values from the US Department of Agriculture that have been adapted for typical Portuguese foods using the Portuguese tables of food composition[16], typical recipes, and data from other studies that analysed the composition of Portuguese foods, as described in detail previously[14,15].

PA assessment

PA was evaluated using the EPIPorto Physical Activity Questionnaire, a questionnaire exploring all professional, domestic and leisure-time activities, detailing the duration and intensity for each activity. This questionnaire was developed using a similar structure to the questionnaire in the European Prospective Investigation into Cancer and Nutrition (EPIC), which showed acceptable reliability and validity[17].

To calculate energy expenditure in PA activity, we used standard metabolic energy equivalent task (MET) values. The MET is defined as the rate of energy expenditure in the activity compared with the resting metabolic rate[18]. Subjects reported the average time spent per day or week on the following types of activities: rest (sleeping/lying awake), transport (to and from work), work, household activities, sedentary, and leisure-time exercise. The activities were categorised as very light, light, moderate and heavy intensity, with an average of 1·5, 2·5, 5·0 and 7·0 METs, respectively[19]. Energy expenditure was estimated by multiplying the related METs by the time spent in each activity (min/d). Full-day energy expenditure included energy expended in all activities during the entire day (sleep, work, household chores and leisure-time activities), while occupational activities included work and household activities. Leisure-time PA included leisure-time activities only (sedentary activities like watching television and different types of exercise).

Participants with less than 10 % of energy expenditure at a moderate or high intensity level (4 METs) during occupational activities, leisure time or throughout the day were categorised as sedentary, following the same options previously described by other authors[20,21]. The 628 kJ (150 kcal) given in the US Surgeon General's report[22] as the increased daily energy expenditure required for substantial health benefits represented, in our adult population, 7·4 % and 6·0 % of the daily average energy expenditure among females and males, respectively. By using a cut-point of 10 % of energy expenditure,

https://doi.org/10.1017/S1368980007001309 Published online by Cambridge University Press

we wanted to be sure to include all sedentary people in the sedentary group rather than the active group.

Statistical analysis

The relationship of dietary intake with PA was analysed by considering full-day energy expenditure, occupational activity and leisure-time activity separately. Nutrient distribution, in active versus sedentary individuals, was analysed by gender, after adjustment for total energy intake, using percentages of total energy intake for the macronutrients and the nutrient residual model for the other nutrients[23]. The *t* test and Kruskal–Wallis test were used to compare quantitative continuous variables, and because multiple comparisons were made, a Bonferroni correction was conducted to have a more stringent *P* value (0·05/34 = 0·001). The association between dietary intake and PA was estimated using multiple linear regression analyses. Beta coefficients of each selected dietary variable and their 99 % confidence interval (CI) were calculated by gender, after adjustment for potential confounders that were associated with PA in the univariate analysis, including age, education, BMI and energy consumption (all continuous variables). In multiple linear regression analyses, as some nutrients (energy, fibre, vitamin C, calcium and magnesium) had a highly skewed distribution, a logarithmic transformation was performed.

Data analysis was conducted using the SPSS® for Windows statistical software package, version 13·0 (SPSS Inc., Chicago, IL, USA).

Results

Participants' characteristics are described in Table 1 according to gender and activity level (active vs. sedentary) for full-day, occupational and leisure-time energy expenditure. When considering full-day energy expenditure, active subjects were significantly younger for both genders, whereas active males were significantly less educated and presented a lower WC than their sedentary counterparts. When viewing energy expenditure in occupational activities, subjects with higher energy expenditure were significantly less educated in both genders and females were younger. In both genders, when considering leisure-time energy expenditure, active subjects were significantly younger, higher educated and had lower BMI and WC compared with sedentary individuals.

When exploring dietary intake and full-day energy expenditure, means of daily nutrient intake did not differ significantly among active and sedentary females (Table 2). Active males presented significantly higher daily intake of energy (10·76 (2570·7) vs. 9·78 (2336·9) MJ/d (kcal/d), $P<0·001$) and a significantly lower intake of protein (16·9 vs. 17·6 % of energy, $P<0·001$) than sedentary males.

When reviewing dietary intake and energy expenditure in occupational activity (Table 3), no significant

Table 1 Characteristics of participants according to active versus sedentary* individuals considering full-day energy expenditure, occupational and leisure-time physical activity, by gender

Full-day energy expenditure

	Females					Males				
	Active		Sedentary			Active		Sedentary		
	N = 163 (11·0 %)		*N* = 1320 (89·0 %)			*N* = 174 (18·9 %)		*N* = 747 (81·1 %)		
	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
Age (years)	44·6	12·4	52·9	14·9	<0·001	49·9	15·1	53·7	15·5	0·003
Education (years)	7·7	4·9	8·4	5·3	0·293	8·1	4·5	9·4	4·8	0·002
BMI (kg/m^2)	27·0	4·7	27·1	5·2	0·906	25·9	3·6	26·4	3·9	0·250
WC (cm)	84·3	12·4	86·4	13·0	0·071	91·1	10·2	93·3	10·8	0·018
Smokers, *n* (%)	35 (21·5)		228 (17·3)		0·184	54 (31·0)		267 (35·7)		0·240

Occupational activity

	Females					Males				
	Active		Sedentary			Active		Sedentary		
	N = 140 (9·4 %)		*N* = 1343 (90·6 %)			*N* = 164 (17·8 %)		*N* = 757 (82·2 %)		
	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
Age (years)	45·4	11·5	52·7	15·0	<0·001	52·0	14·9	53·2	15·0	0·480
Education (years)	6·7	4·4	8·5	5·3	0·001	7·3	4·1	9·6	4·8	<0·001
BMI (kg/m^2)	27·6	4·7	27·0	5·2	0·056	26·2	4·0	26·3	3·8	0·996
WC (cm)	86·0	12·3	86·2	13·0	0·962	92·3	11·1	93·0	10·6	0·828
Smokers, *n* (%)	32 (22·8)		228 (17·2)		0·101	53 (32·3)		240 (37·1)		0·250

Leisure-time activity

	Females					Males				
	Active		Sedentary			Active		Sedentary		
	N = 248 (16·9 %)		*N* = 1235 (83·3 %)			*N* = 162 (17·6 %)		*N* = 759 (82·4 %)		
	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
Age (years)	45·7	15·4	53·3	14·4	<0·001	44·2	15·2	54·9	14·9	<0·001
Education (years)	11·9	4·8	7·7	5·0	<0·001	11·7	4·4	8·6	4·7	<0·001
BMI (kg/m^2)	25·2	4·4	27·5	5·2	<0·001	25·6	3·7	26·4	3·9	0·001
WC (cm)	80·3	10·8	87·3	13·0	<0·001	89·8	10·1	93·6	10·7	<0·001
Smokers, *n* (%)	48 (19·4)		214 (17·5)		0·496	63 (38·9)		251 (33·5)		0·192

SD, standard deviation; BMI, body mass index; WC, waist circumference.
*Sedentarism was defined as spending less than 10 % of time in activities requiring ≥4 METs (metabolic energy equivalent tasks).

Table 2 Daily dietary intake (adjusted for total energy intake) of active versus sedentary individuals considering full-day energy expenditure, by gender

	Full-day energy expenditure									
	Females					Males				
	Active		Sedentary			Active		Sedentary		
	$N = 163$ (11·0 %)		$N = 1320$ (89·0 %)			$N = 174$ (18·9 %)		$N = 747$ (81·1 %)		
	Mean	SD	Mean	SD	P	Mean	SD	Mean	SD	P
Energy (kcal)	2145·9	538·7	2082·6	501·7	0·258	2570·7	592·8	2336·9	576·1	<0·001
(MJ)	8·98	2·25	8·71	2·10		10·76	2·48	9·78	2·41	
Carbohydrates (%E)	49·6	6·7	50·1	5·9	0·325	46·4	6·7	47·1	6·8	0·139
Protein (%E)	19·0	2·7	18·9	2·3	0·658	16·9	2·3	17·6	2·4	<0·001
Fat (%E)	30·1	4·5	29·9	4·4	0·640	28·0	4·4	28·4	4·7	0·233
Saturated fat (%E)	9·4	1·9	9·3	2·0	0·821	8·6	1·8	8·8	2·0	0·359
Monounsaturated fat (%E)	13·0	2·5	12·9	2·3	0·917	12·1	2·1	12·3	2·3	0·238
Polyunsaturated fat (%E)	5·0	1·0	4·9	0·8	0·462	4·8	1·0	4·7	0·8	0·511
Alcohol (%E)	2·3	4·1	2·3	3·7	0·816	9·4	8·0	7·8	7·3	0·011
Cholesterol (mg)	294·5	79·1	290·6	75·9	0·928	310·6	73·2	313·1	84·7	0·672
Fibre (g)	22·5	6·4	23·1	6·8	0·489	22·5	6·6	23·2	7·4	0·181
Vitamin C (g)	127·8	56·1	129·2	55·7	0·658	111·9	48·8	116·0	51·8	0·296
Vitamin D (μg)	4·1	2·6	3·9	2·2	0·632	3·7	1·9	3·7	2·0	0·813
Vitamin E (g)	7·5	1·8	7·6	1·6	0·571	7·6	1·9	7·6	1·8	0·786
Folate (μg)	297·4	103·4	292·8	101·5	0·555	294·1	102·5	294·9	99·8	0·616
Calcium (mg)	927·3	353·1	939·4	318·7	0·419	852·8	290·5	873·3	309·3	0·582
Magnesium (mg)	317·3	54·1	320·2	54·7	0·551	345·2	54·0	348·3	57·5	0·623
Iron (mg)	14·6	2·3	14·7	2·4	0·853	16·3	2·5	16·3	2·4	0·554

SD, standard deviation; %E, percentage of energy.

Table 3 Daily dietary intake (adjusted for total energy intake) of active versus sedentary individuals considering occupational activity, by gender

	Occupational activity									
	Females					Males				
	Active		Sedentary			Active		Sedentary		
	$N = 140$ (9·4 %)		$N = 1343$ (90·6 %)			$N = 164$ (17·8 %)		$N = 757$ (82·2 %)		
	Mean	SD	Mean	SD	P	Mean	SD	Mean	SD	P
Energy (kcal)	2146·7	516·7	2083·6	504·8	0·232	2573·4	594·2	2339·4	576·4	<0·001
(MJ)	8·98	2·16	8·72	2·11		10·77	2·49	9·79	2·41	
Carbohydrates (%E)	49·2	6·8	50·1	5·9	0·065	46·0	6·7	47·2	6·8	0·026
Protein (%E)	18·9	2·6	18·9	2·3	0·959	16·9	2·4	17·6	2·3	0·001
Fat (%E)	30·0	4·5	29·9	4·4	0·833	27·9	4·4	28·4	4·7	0·056
Saturated fat (%E)	9·4	1·9	9·3	2·0	0·795	8·5	1·8	8·8	2·0	0·040
Monounsaturated fat (%E)	12·8	2·2	13·0	2·3	0·583	12·1	2·1	12·3	2·3	0·122
Polyunsaturated fat (%E)	5·0	1·0	4·9	0·8	0·073	4·8	1·0	4·7	0·8	0·635
Alcohol (%E)	2·9	4·4	2·2	3·6	0·288	9·9	8·1	7·7	7·3	0·002
Cholesterol (mg)	301·8	83·8	290·5	75·2	0·293	307·5	78·4	316·8	81·4	0·139
Fibre (g)	21·8	6·4	23·1	6·8	0·026	22·3	7·1	22·9	7·0	0·149
Vitamin C (g)	116·4	44·6	130·1	56·6	0·012	108·0	48·1	116·4	51·4	0·021
Vitamin D (μg)	4·0	2·4	3·9	2·2	0·983	3·5	1·8	3·7	2·0	0·425
Vitamin E (g)	7·3	1·7	7·6	1·6	0·024	7·6	2·0	7·6	1·8	0·444
Folate (μg)	288·8	104·7	293·8	101·4	0·365	292·1	109·0	295·3	98·3	0·189
Calcium (mg)	887·0	337·6	943·3	320·7	0·024	839·2	277·6	876·0	311·4	0·335
Magnesium (mg)	310·4	52·2	320·6	54·6	0·040	345·8	55·8	345·8	56·1	0·997
Iron (mg)	14·5	2·2	14·7	2·4	0·539	16·2	2·4	16·4	2·4	0·351

SD, standard deviation; %E, percentage of energy.

differences were observed between active versus sedentary females. Meanwhile, males in occupations with higher energy expenditure had a significantly lower intake of protein (16·9 vs. 17·6 % of energy, $P = 0·001$) and a significantly higher intake of energy (10·77 (2573·4) vs. 9·79 (2339·4) MJ/d (kcal/d), $P < 0·001$) than men in low energy-expending occupations.

With regard to leisure-time PA, females who were active had significantly higher daily intakes of monounsaturated fat (13·6 vs. 12·8 % of energy, $P < 0·001$),

https://doi.org/10.1017/S1368980007001309 Published online by Cambridge University Press

Table 4 Daily dietary intake (adjusted for total energy intake) of active versus sedentary individuals considering leisure-time energy expenditure, by gender

	Leisure-time activity									
	Females					Males				
	Active		Sedentary			Active		Sedentary		
	$N=248$ (16·9 %)		$N=1235$ (83·3 %)			$N=162$ (17·6 %)		$N=759$ (82·4 %)		
	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*
Energy (kcal)	2121·5	532·1	2083·1	500·7	0·261	2484·0	610·0	2359·1	579·0	0·016
(MJ)	8·88	2·23	8·72	2·09		10·39	2·55	9·87	2·42	
Carbohydrates (%E)	49·8	6·0	50·1	6·0	0·420	47·4	6·1	46·9	6·9	0·189
Protein (%E)	19·3	2·5	18·8	2·3	0·016	17·6	2·2	17·5	2·4	0·840
Fat (%E)	30·7	4·3	29·7	4·4	0·002	29·7	4·3	28·1	4·7	<0·001
Saturated fat (%E)	9·4	2·0	9·3	2·0	0·657	9·4	2·0	8·6	2·0	<0·001
Monounsaturated fat (%E)	13·6	2·5	12·8	2·2	<0·001	12·7	2·1	12·2	2·3	0·005
Polyunsaturated fat (%E)	4·9	0·8	4·9	0·9	0·980	4·9	1·0	4·7	0·8	0·068
Alcohol (%E)	1·7	3·1	2·4	3·8	0·133	6·3	6·7	8·5	7·5	<0·001
Cholesterol (mg)	291·3	77·8	290·4	75·7	0·845	318·0	75·6	311·5	84·4	0·309
Fibre (g)	24·5	6·8	22·7	6·7	<0·001	22·6	6·2	23·2	7·4	0·637
Vitamin C (g)	144·9	56·2	125·8	55·0	<0·001	123·6	48·2	113·7	51·9	0·004
Vitamin D (μg)	4.4	2·5	3·8	2·2	<0·001	3·8	2·1	3·6	1·9	0·281
Vitamin E (g)	8·2	1·6	7·5	1·6	<0·001	8·0	2·0	7·6	1·8	0·038
Folate (μg)	322·1	105·2	287·5	100·0	<0·001	294·2	89·5	294·9	102·5	0·788
Calcium (mg)	1027·8	332·8	920·0	377·6	<0·001	954·1	322·0	851·3	297·0	<0·001
Magnesium (mg)	338·3	57·0	316·4	53·4	<0·001	345·9	53·9	348·4	57·6	0·824
Iron (mg)	14·9	2·4	14·6	2·4	0·018	16·1	2·4	16·4	2·4	0·078

SD, standard deviation; %E, percentage of energy.

fibre (24·5 vs. 22·7 g, $P<0·001$), vitamin C (144·9 vs. 125·8 mg, $P<0·001$), vitamin D (4·4 vs. 3·8 μg, $P<0·001$), vitamin E (8·2 vs. 7·5 mg, $P<0·001$), folate (322·1 vs. 287·5 μg, $P<0·001$), calcium (1027·8 vs. 920·0 mg, $P<$ 0.001) and magnesium (338·3 vs. 316·4 mg, $P<0·001$) compared with women who were sedentary during leisure time (Table 4). In the male gender, active individuals had higher intakes of total fat, saturated fat and calcium and a significantly lower consumption of alcohol (6·3 vs. 8·5 % of energy, $P<0·001$) than sedentary individuals.

When we further examined the relationship between dietary intake and full-day energy expenditure in males, and adjusted for age, education, BMI and total energy intake, significant positive associations remained only for energy intake ($\beta=0·07$, 99 % CI 0·006, 0·13) (Table 5). Similar results were observed when exploring energy expenditure in occupational activity.

When enquiring further into the association between leisure-time energy expenditure and dietary intake and adjusting for the main confounders, a significant positive association was observed between leisure-time activity in males and intake of vitamin C ($\beta=0·13$, 99 % CI 0·03, 0·22). In females, positive associations between activity in leisure time and intakes of fibre ($\beta=0·10$, 99 % CI 0·03, 0·16), vitamin C ($\beta=0·12$, 99 % CI 0·02, 0·21), vitamin E ($\beta=0·66$, 99 % CI 0·27, 1·04), folate ($\beta=35·64$, 99 % CI 12·4, 58·8), calcium ($\beta=0·08$, 99 % CI 0·01, 0·14) and magnesium ($\beta=0·06$, 99 % CI 0·02, 0·09) were also observed. On the other hand, an inverse association was identified between leisure-time activity in females and saturated fat ($\beta=-0·47$, 99 % CI $-0·91$, $-0·02$) (Table 5).

Discussion

In our study, a clear relationship between different types of PA and dietary intake seemed to emerge in both genders. Independently of age, education and BMI, higher levels of PA in leisure time were associated with higher intakes of micronutrients and lower intakes of saturated fat, particularly in females.

For total and occupational PA, similar nutrient intake was observed between active and sedentary individuals. The exception was the positive association between total and occupational PA and energy intake in males. The energy expenditure in active females was very small since, globally, this female population is sedentary. This partially explains why sedentary women and active women have similar energy intake and no differences were found in body composition between active and sedentary females.

These results may be partially explained by the fact that total PA in this sample reflected their occupational activities to a large extent, so these two types of activity had a similar pattern of nutrient intake. Most of the subjects categorised as active during the full day were categorised as active during occupational time (80·4 % and 79·9 %, females and males respectively). The same was not observed regarding leisure-time activity. Within the

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Table 5 Increment in mean daily intake (adjusted for total energy intake)* of active versus sedentary individuals, considering full-day energy expenditure, occupational and leisure-time physical activity, by gender

	Females			Males		
	Full-day energy expenditure	Occupational activity	Leisure-time activity	Full-day energy expenditure	Occupational activity	Leisure-time activity
	β (99 % CI)	β (99 % CI)	β (99 % CI)	β (99 % CI)	β (99 % CI)	β (99 % CI)
Energy (kcal)†	0·01 (−0·05, 0·07)	0·02 (−0·04, 0·08)	−0·01 (−0·04, 0·02)	0·07 (0·006, 0.13)	0·08 (0·01, 0·14)	0·01 (−0·05, 0·07)
Carbohydrates (%E)	−0·18 (−1·77, 1·41)	−0·71 (−2·42, 1·00)	0·13 (−1·26, 1·46)	−0·59 (−2·40, 1·22)	−1·02 (−2·89, 0·85)	0·72 (−1·21, 2·65)
Protein (%E)	0·18 (−0·45, 0·81)	0·06 (−0·60, 0·72)	0·42 (−0·12, 0·96)	−0·57 (−1·20, 0·06)	−0·54 (−1·27, 0·05)	0·01 (−0·67, 0·71)
Fat (%E)	−0·11 (−1·25, 1·03)	−0·04 (−1·28, 1·20)	−0·15 (−1·12, 0·84)	−0·48 (−1·65, 0·69)	−0·18 (−1·41, 0·99)	0·28 (−0·96, 1·52)
Saturated fat (%E)	−0·19 (−0·69, 0·31)	−0·05 (−0·60, 0·48)	−0·47 (−0·91, −0·02)	−0·25 (−0·72, 0·22)	−0·12 (−0·60, 0·34)	0·05 (−0·45, 0·55)
Monounsaturated fat (%E)	0·05 (−0·55, 0·65)	−0·08 (−0·74, 0·58)	0·34 (−0·15, 0·85)	−0·17 (−0·77, 0·43)	−0·07 (−0·68, 0·52)	0·15 (−0·49, 0·77)
Polyunsaturated fat (%E)	0·03 (−0·19, 0·25)	0·10 (−0·14, 0·36)	−0·02 (−0·20, 0·18)	0·02 (−0·20, 0·24)	0·08 (−0·15, 0·29)	0·08 (−0·17, 0·33)
Alcohol (%E)	0·12 (−0·86, 1·10)	0·57 (−0·49, 1·67)	−0·17 (−1·00, 0·70)	1·61 (−0·32, 3·54)	1·74 (−0·27, 3·73)	−0·81 (−2·91, 1·21)
Cholesterol (mg)	−7·07 (−27·4, 13·1)	3·05 (−18·7, 24·8)	−10·6 (−28·7, 6·05)	−2·83 (−24·6, 18·9)	−2·29 (−24·8, 19·8)	−11·8 (−35·0, 11·0)
Fibre (g)†	0·02 (−0·04, 0·08)	−0·01 (−0·07, 0·05)	0·10 (0·03, 0·16)	−0·001 (−0·06, 0·06)	−0·02 (−0·08, 0·04)	0·04 (−0·02, 0·06)
Vitamin C (g)†	0·016 (−0·07, 0·11)	−0·06 (−0·15, 0·03)	0·12 (0·02, 0·21)	−0·01 (−0·10, 0·08)	−0·05 (−0·14, 0·04)	0·13 (0·03, 0·22)
Vitamin D (μg)	0·34 (−0·40, 0·36)	0·23 (−0·46, 0·30)	0·64 (−0·04, 0·58)	−0·02 (−0·47, 0·35)	−0·15 (−0·57, 0·25)	0·30 (−0·29, 0·53)
Vitamin E (g)	0·20 (−0·26, 0·62)	−0·07 (−0·49, 0·45)	0·66 (0·27, 1·04)	0·09 (−0·48, 0·52)	0·01 (−0·62, 0·46)	0·56 (−0·02, 1·06)
Folate (μg)	10·31 (−17·0, 37·6)	1·20 (−28·0, 30·4)	35·64 (12·4, 58·8)	2·43 (−24·6, 29·4)	−1·87 (−27·3, 23·5)	8·48 (−20·1, 37·1)
Calcium (mg)†	0·01 (−0·08, 0·10)	−0·01 (−0·11, 0·07)	0·08 (0·01, 0·14)	−0·01 (−0·10, 0·08)	−0·02 (−0·11, 0·07)	0·08 (−0·01, 0·14)
Magnesium (mg)†	0·02 (−0·01, 0·05)	0·000 (−0·04, 0·04)	0·06 (0·02, 0·09)	0·000 (−0·04, 0·04)	−0·002 (−0·04, 0·04)	0·01 (−0·02, 0·04)
Iron (mg)	0·04 (−0·59, 0·67)	−0·05 (−0·74, 0·64)	0·48 (−0·06, 1·02)	0·02 (−0·62, 0·64)	−0·17 (−0·83, 0·49)	−0·008 (−0·70, 0·68)

CI, confidence interval; %E, percentage of energy.
*Multiple linear regression model adjusted for age, education and body mass index.
†Log variable.

subjects who were active during leisure time, a small percentage was categorised as active during occupational time (10·9 % and 16·0 %, females and males respectively) and active during the full day (23·0 % and 35·8 %, females and males respectively).

Most studies relating PA with diet have reported that being physically active is associated with healthy nutritional choices[8,24,25]. However, most of them only considered leisure-time activities, and not the effect of different types of PA.

PA performed at the workplace is not always related to better physical fitness[26], and the association between occupational activity and disease or behavioural health determinants is not clear[27–29]. In our population[30], a protective effect of leisure-time PA on myocardial infarction risk has already been described, but the same protective effect was not found for high levels of full-day energy expenditure or occupational activity.

Some studies[28,31] support the positive association between occupational PA and alcohol intake. Blue-collar workers usually have higher levels of total PA[32] and they seem more frequently to be drinkers than white-collar workers. Another study in older Dutch adults concluded that subjects with higher alcohol intake (% of daily energy intake) had a higher total PA level[33]. When leisure-time PA was used as the estimate in the present study, alcohol consumption presented a negative association. This finding is similar to what was reported in a study of the US population from the 1990 National Health Interview Survey[34], in which the likelihood of displaying a physically active lifestyle during leisure time decreased from moderate drinking to heavier consumption of alcohol, sustaining the idea that leisure activities were associated with moderate drinking habits.

Despite the difference not being statistically significant, it was possible to observe in our study that the mean alcohol intake was always higher in active individuals considering full-day energy expenditure and occupational PA. However, when we analysed leisure time the same relationship was not observed, and the mean alcohol intake was lower in active individuals compared with sedentary ones.

In the present study, strong positive associations were found in females between leisure-time PA and intakes of fibre, vitamins and minerals and an inverse association with saturated fat. A similar positive association with vitamin C was found in males.

Comparable results were observed in the Worcester Area Trial for Counseling in Hyperlipidemia study[8], which evaluated the relationship between leisure-time PA and some selected dietary variables in adults and described that active individuals consumed a lower-fat and more micronutrient-dense diet than their more inactive counterparts.

In a review[35] about micronutrients and their interaction with PA, micronutrient intake was shown to be

https://doi.org/10.1017/S1368980007001309 Published online by Cambridge University Press

proportional to energy intake and people who were more physically active (athletes) presented higher levels of micronutrient intake. In our sample, we found that significantly higher mean intakes of micronutrients were also associated with higher levels of leisure-time activities, particularly in females.

A cross-sectional study in two south-east New England communities[25] showed that moderately and very active participants consumed more fibre, vitamins (A, C, D, E), β-carotene and calcium, eating more fruits and vegetables and less total and saturated fat, than sedentary participants. A similar relationship between exercise participation and dietary intake has been partially supported by data from the Health Professionals' and Nurses' Health Follow-up Studies[9,10], which showed an association between exercise participation and vitamin E intake in both genders. A study[24] exploring the relationships between PA and dietary behaviours among adult members of the Harvard Pilgrim Health Care, the largest managed care organisation in New England, showed that intakes of fruit and vegetables, dietary fibre, calcium, folate and vitamins A, C and E were higher in more active participants currently engaged in moderate or vigorous exercise. In addition, the authors identified determinants of the relationship of sedentary behaviour and sub-optimal diet, and concluded that these two characteristics tend to cluster in individuals who are less educated, not married and of non-white race.

Healthy dietary choices have also been identified in subjects who engage in moderate or vigorous PA during leisure time[24]. In the present study, the participants were classified only as active or sedentary, since the prevalence of sedentarism in the study population was so high[21] that subjects who engaged in moderate/vigorous activities during leisure time (15·6 %) or even in full-day activity (13·9 %) represented a small percentage of the entire cohort. In American adults[24], the differences in the association between diet and PA levels were more pronounced among sedentary and moderately active adults than among moderately and vigorously active adults. The possible loss of information, by only analysing two categories of PA (sedentary and active) in this study, does not seem to be relevant.

Contrary to the other types of activity, being active during leisure time is related to better choices regarding dietary intake. Independently of education level this association is clear, namely in females. This suggests that people who have some concern about being active during leisure time probably have similar concern regarding healthier dietary choices and this does not happen in people who are active during occupation time.

In the present study, the age ranged between 18 and 92 years old and the usual age of retirement in Portugal is 65 years. Although occupational PA did not reflect only the professional side of each individual, because household chores were added to define occupational activities, the probability of subjects older than 65 years being active in occupational activities is lower. A re-analysis without individuals older than 65 years showed similar results to the previous univariate analysis (results not shown).

Since we assessed PA and diet with questionnaires only, misclassification of these behaviours could have occurred. However, information was collected by trained interviewers using a structured questionnaire in order to minimise the potential bias of self-reporting.

Considering the validation and reproducibility of the FFQ, the comparison with fatty acids (as % of total fat) evaluated by dietary records and estimates of adipose tissue composition were described previously[15] and for the remaining nutrients the Spearman correlation coefficients between the FFQ and the 7-day dietary records ranged from 0·33 to 0·88 for vitamin E and alcohol, respectively (mean for 17 nutrients = 0·56). Also, the correlation coefficients between two FFQs (time interval of 1 year) ranged between 0·35 and 0·88 for folate and alcohol, respectively (mean for 17 nutrients = 0·58). Classification agreement, considering the same quartile of intake, ranged from 30·1 % (*trans* isomers) to 52·7 % (saturated fat), with a mean of 42 %. The mean proportion of misclassification into extreme quartiles of intake was 3 %[14].

Regarding the measurement properties of the PA questionnaire used, it is important to reinforce that the EPIPorto questionnaire was developed based on the EPIC questionnaire which was shown to be valid and reliable for a similar adult sample[17]. Furthermore, data on validity and reproducibility of the EPIPorto questionnaire ($n = 114$) showed Spearman's correlation coefficients between the questionnaire and four 7-day physical activity diaries of 0·56, 0·88 and 0·78 for total, occupational and leisure-time PA, respectively. Corresponding correlations between two applications of the questionnaire (time interval of 3 months) were 0·86, 0·91 and 0·80. These data support the good interpretation of the results.

Another possible limitation could result by the estimate of associations using cross-sectional data. However, because we aimed to estimate the association between these two behaviours rather than its direction, the fact that we used cross-sectional data does not seem to be a major drawback in this study.

Conclusions

The current study supports the presence of differences in the relationship between dietary intake and PA activity, according to different types of activity.

Subjects who were active during leisure time had substantially higher daily intakes of micronutrients and balanced choices regarding nutrient intake.

The present findings could have implications for further epidemiological research on PA and diet, emphasising the relevance of evaluating the effect of different types of PA on health determinants.

https://doi.org/10.1017/S1368980007001309 Published online by Cambridge University Press

Acknowledgements

Sources of funding: This study was funded by the Fundação para a Ciência e a Tecnologia, Praxis POCTI/ESP/42361/2001 and POCI/SAU-ESP/61160/2004.

Conflict of interest declaration: There are no conflicts of interest.

Authors' contributions: M.C. designed the study, performed the statistical analysis and drafted the manuscript. C.L. conceived the study, and participated in the design, interpretation and review of the paper. Both authors read and approved the final manuscript.

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