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Dietary and socio-economic factors associated with overweight and obesity in a southern French population

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Abstract

Objective: To investigate the socio-economic and dietary factors associated with overweight and obesity, respectively, in southern France.
Design: Cross-sectional analysis of socio-economic, lifestyle and nutritional characteristics of a representative population sample. A questionnaire elicited information on anthropometric measurements, socio-economic factors, physical activity, tobacco use, and alcohol and food intakes. Non-parametric tests, multiple linear regression models and correspondence factorial analysis (CFA) were used to estimate the association of the various factors with overweight and obesity.
Setting: French Southwest and Mediterranean areas.
Subjects: In total, 1169 subjects (578 women and 552 men), aged 30–77 years, were recruited at random.
Results: Overweight and obesity were associated with age and education in both genders, reproductive factors in women and tobacco use in men. A few dietary factors were identified (high energy intake and low intake of carbohydrates), but all these variables explained little of the variation (18.5% in women and 14.6% in men). The CFA further investigated the association of lifestyle and nutritional factors, giving more weight to nutritional behaviour for overweight men and women. Factors for obesity differed from those for overweight by being different in men and women, possibly related to psychological behaviour, and there were fewer of them, suggesting an insufficient coverage by the usual questionnaires.
Conclusions: Overweight and obesity appear as two different entities. Energy imbalance induced by various lifestyle factors plays a major role in the development of overweight, whereas obesity represents a more complex entity where psychological and genetic factors that are difficult to assess may be more important. General nutritional guidelines appear more adapted to the prevention of overweight than to that of obesity, and individual counselling to the prevention of obesity.

Keywords
Overweight
Obesity
Socio-economic factors
Dietary factors
Lifestyle factors
Correspondence factorial analysis

Obesity has reached epidemic proportions in many countries of the Western world[1]. France has a proportion of overweight and obesity among the lowest for European countries[2,3]. Within France, women from southern regions display the lowest percentage of overweight and obesity (F Clavel, personal communication). However, a recent report on the body mass index (BMI) of young army recruits showed that the prevalence of overweight and obesity was increasing more rapidly in individuals from the Mediterranean region[4] compared with other French regions, thus opening a debate on the relevance of the Mediterranean diet as a nutritional model[5]. As obesity is strongly associated with the main causes of morbidity and mortality in the Western world – cardiovascular disease, cancer and diabetes[6,7], its reduction is a necessary health goal. Environmental determinants coupled with genetic susceptibility are the key factors contributing to a rise in overweight and obesity, and a greater understanding of these factors would lead to the development of more appropriate health policies. In this study, conducted in French Mediterranean and Southwest regions, we focused on socio-economic and individual factors (diet and physical activity) and their potential relationship with overweight and obesity, respectively.

Subjects and methods

Subjects

The MEDHEA study (Mediterranean Diet and Health)[8–11] randomly recruited 1521 subjects aged 20–77 years from electoral lists in Toulouse, Marseille and the Hérault and Tarn regions, between January 1994 and November 1996. Twenty-seven per cent of subjects responded to the letter

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sent inviting them to participate in the study, and 48% of these agreed to participate.

We selected 1169 subjects aged between 30 and 77 years, because the distribution of BMI by age showed few overweight (8.0%) and obese (1.8%) subjects below 30 years of age. Underreporters were identified as men declaring a daily intake <6270 kJ, and women <5200 kJ. However, because food-frequency questionnaires (FFQs) are known to underestimate energy intake and because aged sedentary subjects might live on low energy intake, reporting of these subjects was ultimately re-evaluated according to their physical activity in order to minimise exclusions. When energy expenditure related to physical activity, estimated according to Ainsworth *et al.*[12], was not >10% of energy intake, the subjects were re-integrated into the study sample. None of the excluded subjects was obese. The final sample was comprised 578 women and 552 men.

Questionnaire

The questionnaire elicited information on sociodemographic factors, anthropometric characteristics (self-declared) and food intake, estimated by frequency of consumption (ranging from twice a day to once per month). The 162 foods or food groups were quantified using a set of photographs. This quantitative FFQ has been validated by correlations of energy and macronutrient intakes (Pearson correlation coefficient from 0.65 for vitamin E to 0.37 for monounsaturated fatty acids, with 0.57 for energy)[13–15]. Questions on occupational and leisure physical activity were included, organised as previously reported in the literature[16–18]. Subjects indicated their type of work, in which they were assumed to be engaged for 38 h per week (the usual weekly work period at that time; no subject declared part-time work), and the type of sport with time spent per week. Each activity was characterised by a score according to Ainsworth *et al.*[12] and a metabolic equivalent per day (MET day^{-1}) calculated according to Falkner *et al.*[19] for work physical activity and leisure physical activity as follows:

$$\text{work physical activity (MET day}^{-1}) = (\text{work MET score} \times 38)/7$$

and

$$\text{leisure physical activity (MET day}^{-1}) = (\text{leisure MET score} \times \text{time spent per session} \times \text{number of sessions per week})/7.$$

Statistics

Missing data from 0.2% (alcoholic beverage intake) to 29% (use of oral contraceptives) of subjects were corrected to 0 to 0.6% using the cold-deck (comparison with similar studies on the same sample) and deductive (logical verification) methods[20].

SAS version 8.2 (SAS Institute, Cary, NC, USA) was used for statistical analysis.

Chi-square tests were used to analyse differences in the distribution of age (two categories: 30–49 years and ≥50 years, selected after considering the distribution of BMI by 5-year age groups – overweight increased from 50 years and above in women and from 30 years and above in men; there was no such increase in obesity in both sexes), socio-economic factors comprising education (<high school degree, ≥high school degree), occupational activity (yes, no), occupational status (none, manual workers, white-collar workers and executives, employees and blue-collar workers), marital status (single, couple) and smoking habits (never, current smoker, ex-smoker), and reproductive life-related variables for women, categorised according to their relevance to breast cancer risk (age at menarche (9–11 years, 12–13 years, 14–17 years); parity (<3, ≥3); menopausal status (yes, no); use of oral contraceptives (yes, no); and hormone replacement therapy (HRT) use (yes, no)), across normal weight (<25 kg m^{-2}), overweight (≥25 to <30 kg m^{-2}) and obese (≥30 kg m^{-2}) BMI categories. Husband's occupational status was attributed to women without occupation in order to estimate their social status (but was not used for their physical activity estimation). Differences in median values of nutrient consumption and physical activity among the three BMI categories were analysed using the non-parametric Kruskal–Wallis test. Factors shown to be significantly associated with BMI, in at least one sex, were incorporated into a multiple linear regression analysis. Two models were tested, one introducing energy intake and the other replacing energy by the percentage of energy provided by each macronutrient.

To characterise the subjects in each BMI class, we used correspondence factorial analysis (CFA) using the correspondence analysis procedure in SAS. The subjects in each BMI category were analysed against energy and macronutrient intakes plus each variable shown to be significant in the univariate analysis. The association is expressed as the value of the distance on the axes and the proximity to the axes. Only distances on the axis ≥0.10 were considered.

Results

Among the 578 women, 16.4% were overweight and 6.4% were obese. Among the 552 men, 41.5% were overweight and 4.2% were obese. Table 1 shows that the distribution of the three BMI categories was significantly different across age, education, occupational activity and occupational status categories in the sample of women. The distribution of the three categories of BMI was also significantly different across categories of menopausal

Table 1 Distribution of sociodemographic factors and smoking habits among normal-weight (body mass index (BMI) $<25\,kg\,m^{-2}$), overweight (BMI ≥ 25 to $<30\,kg\,m^{-2}$) and obese (BMI $\geq 30\,kg\,m^{-2}$) women

	Normal weight		Overweight		Obese		
Factor	*n*	%	*n*	%	*n*	%	*P*-value
Age (years)							
30–49	253	87.8	21	7.3	14	4.9	
≥ 50	193	66.6	74	25.5	23	7.9	<0.001
Occupational activity							
Yes	165	66.0	64	25.6	21	8.4	
No*	281	85.7	31	9.4	16	4.9	<0.001
Occupational status							
None	42	67.7	13	21.0	8	12.9	
Manual workers	12	52.2	10	43.5	1	11.7	
White-collar workers and executives	180	83.3	24	11.1	12	5.5	
Employees and blue-collar workers	212	76.8	48	17.4	16	5.8	<0.001
Education							
< High school degree	171	68.1	61	24.3	19	7.6	
≥ High school degree	274	84.0	34	10.4	18	5.5	<0.001
Marital status							
No	102	15.3	20	15.3	9	6.9	
Yes	344	16.8	75	16.8	28	6.3	NS
Smoking							
Never	269	74.9	69	19.2	21	5.8	
Current	97	85.8	9	8.0	7	6.2	
Ex-smoker	80	75.5	17	16.0	9	8.5	NS
Age at menarche (years)							
9–11	77	67.0	25	21.7	13	11.3	
12–13	228	80.0	41	7.4	16	5.6	
14–17	139	79.0	29	16.5	8	4.5	<0.05
Parity							
< 3	335	79.2	64	15.1	24	5.7	
≥ 3	111	71.6	31	20.0	13	8.4	NS
Menopausal status							
Yes	186	66.9	70	25.2	22	7.9	
No	260	86.7	25	8.3	15	5.0	<0.0001
Use of oral contraceptives							
Yes	290	85.5	37	10.9	12	3.5	
No	156	65.3	58	24.3	25	10.5	<0.0001
HRT use							
Yes	75	67.0	29	25.9	8	7.1	
No	371	79.6	66	14.2	29	6.2	<0.01

HRT – hormone replacement therapy; NS – not significant.
* Retired or unemployed.

status, use of oral contraceptives and HRT use, as expected given the high level of correlation of these variables with age. With regard to age at menarche, which is independent of the age categories within the sample, a higher proportion of overweight and obesity was found in women with an early menarche.

BMI also increased with age and decreased with education level in the sample of men (Table 2). But the distribution of BMI in each age category was different between men and women, with more overweight in the younger men than in the younger women and more obesity in the older women than in the older men. The percentage of overweight and obese men was comparable among the categories of occupational activity and status, whereas it was significantly different among the categories of smoking and marital status, both factors showing no association with BMI in women.

Very few dietary variables were different among the three categories of BMI. There was no significant difference in energy consumption. In women the median energy intake was very close in the three BMI categories, around 7300 kJ day^{-1}, but the minima increased with BMI category whereas the maxima remained very close (3182.4–18 509.3, 3513.8–17 803.2 and 3760.2–17 881.5 kJ day^{-1} for normal-weight, overweight and obese women, respectively). Such a tendency was also observed for fat intake as measured in g day^{-1}. However, when expressed as a percentage of total energy intake, obese women declared the highest median consumption of saturated fatty acids (13.2, 12.2 and 13.6%, respectively; $P=0.05$) and polyunsaturated fatty acids (7.6, 8.1 and 9.1%, respectively; $P<0.05$). Physical activity appeared to be lower in obese women, with a borderline significant lower activity at work ($P=0.08$) and significantly less leisure-time physical activity ($P=0.02$); the latter was nil in 46.7% of obese women.

In men as in women, there was no significant difference in energy consumption. However, obese men always declared slightly higher energy intake (median daily energy intake in normal-weight, overweight and obese

Table 2 Distribution of sociodemographic factors and smoking habits among normal-weight (body mass index (BMI) $< 25\,kg\,m^{-2}$), overweight (BMI ≥ 25 to $< 30\,kg\,m^{-2}$) and obese (BMI $\geq 30\,kg\,m^{-2}$) men

	Normal weight		Overweight		Obese		
Factor	*n*	%	*n*	%	*n*	%	*P*-value
Age (years)							
30–49	161	64.9	79	31.9	8	3.2	
≥ 50	139	45.8	150	49.3	15	4.9	< 0.001
Occupational activity							
Yes	101	48.1	98	46.7	11	5.2	
No*	199	58.2	131	38.3	12	3.5	NS
Education							
< High school degree	129	48.0	124	46.1	16	5.9	
≥ High school degree	170	60.1	105	37.1	7	2.5	< 0.01
Occupational status							
Manual workers	37	48.7	34	44.7	5	6.6	
White-collar workers and executives	109	56.1	78	40.2	7	3.6	
Employees and blue-collar workers	150	54.1	116	41.9	11	4.0	NS
Marital status							
No	49	72.1	17	25.0	2	2.9	
Yes	248	72.1	211	45.0	21	4.4	< 0.01
Smoking							
Never	118	60.5	72	36.9	5	2.6	
Current	85	57.8	57	38.8	5	3.4	
Ex-smoker	96	45.9	100	47.8	13	6.2	< 0.05

NS – not significant.
*Retired or unemployed.

men: 9303, 9632 and 11 523 kJ, respectively) as well as higher intakes of total fat and specific fatty acids, expressed in $g\,day^{-1}$ or in percentage of total energy intake. Only carbohydrate intake showed a significant difference, with less contribution to total energy consumption in overweight and obese men than in men with a normal BMI (daily % of total energy intake for normal-weight, overweight and obese men: 42.7, 41.3 and 40.2, respectively; $P < 0.05$). Alcohol intake as an absolute amount (median for normal-weight, overweight and obese men: 11.6, 13.7 and 9.5 $g\,day^{-1}$, respectively; $P = 0.05$) as well as a percentage of energy (3.3, 4.2 and 2.9%, respectively; $P < 0.05$) was significantly lower in obese men and higher in overweight ones. There was no difference among men with regard to physical activity.

Whereas daily energy intake considered by sex did not appear to differ among the BMI categories, it was significantly higher in overweight subjects for the total sample (median (min–max): normal-weight, 8270 (3182–27 703) kJ; overweight, 8935 (3514–28 592) kJ; obese, 8341 (3760–20 512) kJ; $P < 0.01$).

The first multiple regression model for women included significant socio-economic factors, reproductive life-related factors and energy intake. Age was the strongest explanatory variable (10%) followed by age at menarche, education level and use of oral contraceptives, adding up to 14.8%. In model 2, energy intake was replaced by the percentage of energy provided by each macronutrient. In this model, R^2 reached 18.5% as carbohydrate was negatively associated with BMI with r^2 approaching 2% (Table 3).

Table 3 Multiple regression models for body mass index as the dependent variable and dietary factors and other non-dietary factors as independent variables in women and men

	Women		Men	
	r^2 (%)	*P*-value	r^2 (%)	*P*-value
Model 1				
Age	10.0	< 0.0001	6.4	< 0.0001
Age at menarche	2.4	< 0.0005		
Marital status			1.9	< 0.001
Oral contraceptives	1.1	< 0.05		
Education	1.4	< 0.005	0.8	< 0.05
Ex-smoker			0.9	< 0.05
Physical activity at work			0.5	< 0.1
R^2	14.8		10.6	
Model 2				
Age	11.4	< 0.0001	6.4	< 0.0001
Age at menarche	2.1	< 0.0005		
Oral contraceptives	0.9	< 0.05		
Carbohydrate (% of energy)	1.9	< 0.0005	3.6	< 0.0001
Marital status			1.7	< 0.01
Education	2.2	< 0.0005	1.0	< 0.01
Smoking status			0.8	< 0.05
Protein (% of energy)			0.6	< 0.05
Physical activity at work			0.5	< 0.1
R^2	18.5		14.6	

Women – *Model 1:* age (years), education (< high school degree, ≥ high school degree), age at menarche, parity, menopausal status (yes, no), oral contraceptives (yes, no), hormone replacement therapy (HRT) (yes, no), energy (kJ); *Model 2:* age (years), education (< high school degree, ≥ high school degree), age at menarche, parity, menopausal status (yes, no), oral contraceptives (yes, no), HRT (yes, no), fat % of energy, carbohydrate % of energy, protein % of energy.
Men – *Model 1:* age (years), education (< high school degree, ≥ high school degree) smoking status, (current, ex-, non-smoker), marital status (yes), energy (kJ), physical activity at work MET, leisure physical activity; *Model 2:* age (years), education (< high school degree, ≥ high school degree), smoking status, (current, ex-, non-smoker), marital status (yes), fat % of energy, carbohydrate % of energy, protein % of energy, physical activity at work MET, leisure physical activity.

The first multiple regression model for men included significant socio-economic factors, energy intake, and physical activity at work and at leisure. Age was the strongest explanatory variable but with a rather low coefficient (6.4%). Other factors were marital status, smoking status, education level and work physical activity, adding up to $R^2 = 10.6\%$. In model 2, energy intake was replaced by the percentage of energy provided by each macronutrient as outlined above for women. In this model, R^2 reached 14.6% as carbohydrate was negatively associated with BMI with $r^2 = 3.6\%$ (Table 3). Other models, including ones with separated fatty acids, olive oil and dietary fibre were computed, but none reached a higher R^2 than model 2.

Faced with the findings from the multiple linear regression analyses, two explanations were possible. Either the significant factors masked other factors less precisely estimated (e.g. socio-economic factors versus dietary factors) or the relationship of the considered factors to BMI was not linear, i.e. they could be associated differently with overweight and obesity.

We used CFA to investigate these hypotheses (Figs 1 and 2) . In women (Fig. 1), axis 1 explained 88.9% of overweight, which is strongly associated to this axis together with ≥50 years of age, menopause, HRT use and lower level of education. No use of oral contraceptives, parity ≥3 children and energy intake >10 460 kJ were less tightly associated. Symmetrically, young age, no menopause, higher level of education and use of oral contraceptives were negatively represented on axis 1. In addition, tobacco use, physical activity at work and white collar/executive occupational status were negatively represented on axis 1.

Obesity was equally represented on axes 1 and 2, with axis 2 providing 11.1% of explanation. Young age at menarche (9–11 years) and no occupation were equally represented on both axes, whereas leisure-time physical activity was represented only on axis 2. A low activity was positively associated and a high activity negatively associated with obesity. The case of the variable 'manual worker' is peculiar in that it was positively associated with overweight but negatively with obesity.

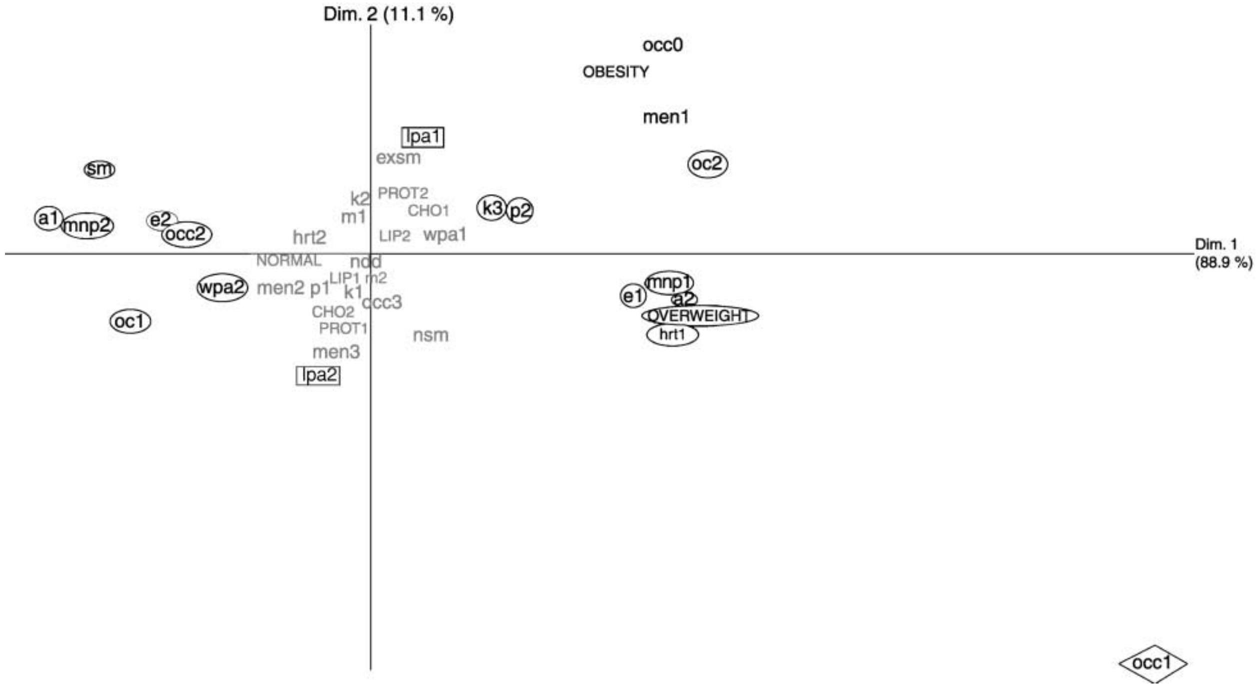

Fig. 1 Correspondence factorial analysis of the relationship between body mass index (BMI) in normal (BMI < 25 kg m^{-2}), overweight (BMI ≥25 to <30 kg m^{-2}) and obese (BMI ≥ 30 kg m^{-2}) women and dietary, reproductive life-related and socio-economic variables. Age: a1, 30–49 years; a2, ≥50 years. Occupational status: occ0, none; occ1, manual workers; occ2, white-collar workers and executives; occ3: employees and blue-collar workers. m, marital status. e1, low level of education; e2, high level of education. sm, smoker; exsm, ex-smoker; nsm, non-smoker. k1, low energy intake (<8368 kJ); k2, medium energy intake (≥8368 to ≤10 460 kJ); k3, high energy intake (>10 460 kJ). PROT1, <15.4% of energy provided by protein; PROT2, ≥15.4% of energy provided by protein. CHO1, <42.5% of energy provided by carbohydrate; CHO2, ≥42.5% of energy provided by carbohydrate. LIP1, <39.1% of energy provided by lipids; LIP2, ≥39.1% of energy provided by lipids. wpa1, <14.7 MET day^{-1} working physical activity; wpa2, ≥14.7 MET day^{-1} working physical activity. lpa1, <1.6 MET day^{-1} leisure physical activity; lpa2, ≥1.6 MET day^{-1} leisure physical activity. men1, early menarche (<12 years); men2, menarche at 11–13 years; men3, menarche at ≥14 years. mnp1: menopause yes; mnp2, menopause no. oc1, oral contraceptives yes; oc2, oral contraceptives no. hrt1, hormone replacement therapy (HRT) yes; hrt2, HRT no. p1, <3 children; p2, ≥3 children. No surrounding means an equal representation on both axes; a circle surrounds variables associated with overweight on axis 1; a square surrounds variables associated with obesity on axis 2; and a diamond indicates an association with overweight and obesity of opposite sign for the variable. Values of the representation on the axes are given together with the square cosines in Appendix A; variables in grey have a coefficient <0.10

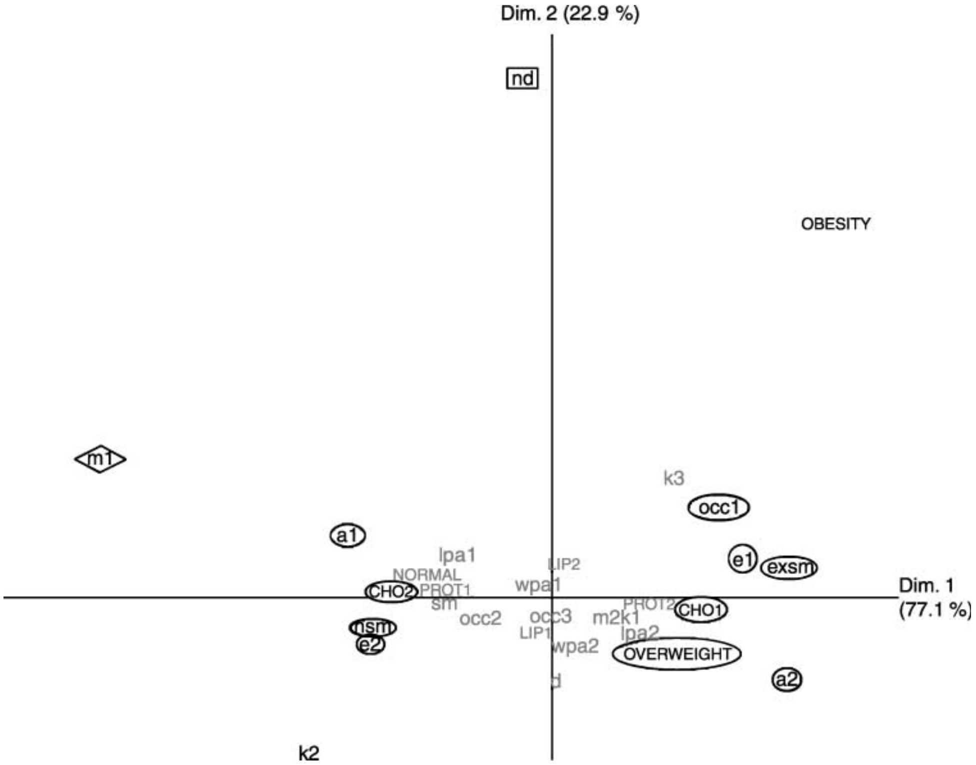

Fig. 2 Correspondence factorial analysis of the relationship between body mass index (BMI) in normal (BMI < 25 kg m^{-2}), overweight (BMI ≥25 to <30 kg m^{-2}) and obese (BMI ≥ 30 kg m^{-2}) men and dietary and socio-economic variables. Age: a1, 30–49 years; a2, ≥50 years. Occupational status: occ1, manual workers; occ2, white-collar workers and executives; occ3, employees and blue-collar workers. m, marital status. e1, low level of education; e2, high level of education. sm, smoker; exsm, ex-smoker; nsm: non-smoker. k1, low energy intake (<8368 kJ); k2, medium energy intake (≥8368 to ≤10 460 kJ); k3, high energy intake (>10 460 kJ). PROT1, <14.4% of energy provided by protein; PROT2, ≥14.4% of energy provided by protein. CHO1, <42.0% of energy provided by carbohydrate; CHO2, ≥42.0% of energy provided by carbohydrate. LIP1, <37.0% of energy provided by lipids; LIP2, ≥37.0% of energy provided by lipids. wpa1, <21.5 MET day^{-1} working physical activity; wpa2, ≥21.5 MET day^{-1} working physical activity. lpa1, <2.2 MET day^{-1} leisure physical activity; lpa2, ≥2.2 MET day^{-1} leisure physical activity. No surrounding means an equal representation on both axes; a circle surrounds the variables associated with overweight on axis 1; a square surrounds variables associated with obesity on axis 2; and a diamond indicates an association with overweight and obesity of opposite sign for the variable. Values of the representation on the axes are given together with the square cosines in Appendix B found on previous page

In men (Fig. 2), axis 1 was less explicative (77.1%) and axis 2 more so (22.9%) than in women. Overweight was better represented on axis 1, associated with age ≥50 years, a low intake of carbohydrate (<41.98% of total energy intake), being an ex-smoker, low level of education and being a manual worker. Hence, young age, being a non-smoker, having a higher level of education and a high intake of carbohydrate (≥41.98%) were inversely associated with overweight.

Obesity was equally represented on both axes. Being a non-drinker was the only variable associated with axis 2. An energy intake <10 460 kJ was negatively associated both with overweight and obesity. Being single was negatively associated with overweight and slightly positively associated with obesity.

Discussion

With regard to the prevalences of overweight (28.7%) and obesity (7%), our results are comparable to those of the French sub-sample of a study[21] conducted in the European Union in 1997 on about 1000 subjects (men and women: 24.0 and 5.3%, respectively), and confirm that the French, together with the Swedes and Italians, have the lowest prevalence of obesity. This supports the validity of our sample. Our study focused on southern France and indicated that obesity prevalence appears to be lower than national levels, whereas overweight prevalence is higher. Our female sample can be compared with the results of the French E3N–EPIC study (European Prospective Investigation into Cancer and Nutrition; F Clavel, personal communication), which showed that women from southern regions had the lowest prevalence of overweight and obesity. However, their findings, based on a cohort comprised mostly of teachers recruited in the same region (Hérault), showed prevalences of overweight (11.4%) and obesity (2.9%) even lower than those found in the present study, possibly because their subjects had a higher level of education whereas our sample tends to be representative of the general population. A further study of men and women aged 35–64 years was conducted in Southwest France between 1985 and 1997[22]. The prevalences of overweight and obesity were 25% and 11% in women, and 50% and 13% in men, in the years corresponding to those of the MEDHEA study, all percentages being higher than our figures, especially for obesity. However, they observed the same discrepancy between women and men concerning the age when BMI increases: overweight is only 15% and obesity 4% in women below 45 years, whereas it is already 45% and 7% in men at this age. It should be noted that only 15% of our sample were recruited from the Southwest region.

Several studies have underlined the importance of socio-economic factors and physical activity either by studying them only[21,23,24] or by showing their stronger weight in multiple regression analyses that also included dietary variables[25]. All studies reported the positive association of age and lower education with overweight and/or obesity, as we observe in our multiple regression analysis. When stratified for gender in these studies, menopause and parity (≥ 3 children) were associated[25], and higher socio-economic status inversely associated[24], with obesity in women, and being an ex-smoker only in men, in line with our results.

In the present study dietary factors were only weakly associated with BMI, and the negative association of carbohydrate intake with BMI appeared to be the only significant dietary factor. Comparable findings were reported by Gonzalez *et al.*[25], who showed that carbohydrate intake as a percentage of energy was negatively associated with BMI with a higher r^2 than fat intake as a percentage of energy (0.3 and 0.04%, respectively). There are several hypotheses to explain this very loose association between dietary factors and BMI in epidemiological studies. Several epidemiologists[26–28] are convinced that it is true. However, on the one hand, it contradicts experimental diet studies on volunteers (as reviewed in reference 29) and, on the other, epidemiological studies are flawed with biases. The first of these biases is related to the non-reliability of dietary assessment in obese subjects. In spite of the care taken in the elimination of underreporters, quantitative bias is difficult to avoid[30,31]. The second bias is that these findings are generally based on cross-sectional studies, which prohibits defining a temporal sequence between diet and obesity. Therefore, sociodemographic factors, which are more precisely estimated and more stable over time, override dietary factors within statistical analyses.

Another consideration is that overweight and obesity may be two different entities, which are not represented by the linearity of increasing BMI. In a previous study on this sample, overweight was associated with a good quality dietary index but not obesity[11]. Therefore the variability of each deserves to be analysed separately. A study[23] conducted with a sample of 515 young Kuwaiti college men with 11% obesity computed the logistic regression both on overweight and obesity with socio-economic factors. The author found that being married was a factor significantly associated with overweight and not with obesity in this young sample. In the MEDHEA study the sub-sample of obese subjects was too small to provide robust results in a logistic regression, hence CFA was used to allow for the separate analysis of overweight and obesity on the total samples of women or men. The results indicated that patterns are not the same for overweight and obesity.

For overweight, energy imbalance seems the main factor; there is a high energy intake, which might be aggravated by unbalanced intakes of macronutrients (insufficient carbohydrates). A high energy intake is usual in manual workers and their spouses, and in less educated subjects; it is also generally more common when living as a couple especially for men, as described by Al-Isa[23]. It is well known that smokers tend to have lower weights and that ex-smokers gain weight. These factors are grossly similar in both sexes. In women, factors related to reproductive life – menopause, taking HRT but not oral contraceptives and having more than 3 children – are also associated with overweight. This is in line with the sudden rise in overweight prevalence at 50 years of age observed in women, when estimated through 5-year age categories, which suggests a relationship with hormonal changes and/or changes in the psychological attitude of menopausal women towards their shape. These variables may also be confounded by age.

By contrast, the factors related to obesity are much less clearly identified, and they are different between women and men. They are associated with both obesity and overweight, or are specifically related to obesity, or they display opposite relationships with overweight and obesity.

In women, being without occupational activity and menarche occurring at an early age were equally associated with obesity and overweight. Both variables suggest a relationship with diet: the first situation might induce disorders of eating behaviour, and a high-energy diet has been linked to early menarche[32,33]. Thus, this is an indication that an energy-rich diet occurring early in adolescence is a factor for overweight and obesity. It is interesting to note that age at menarche decreases by birth cohort from 1930 to 1950[34], together with an increasing rate of obesity prevalence. High leisure-time physical activity is the only factor specifically associated with obesity, as shown by others[35]. In contrast, whereas being a manual worker or a manual worker's spouse is associated with overweight, it is inversely associated with obesity. The MEDHEA study indicated[11] that manual workers' food habits are characterised by a good quality dietary index, low SFA and cholesterol, and high intakes of fruits, vegetables, fish and olive oil, independently of the quantity. Such a dietary profile, although it might induce overweight if too abundant, may prevent the development of characterised obesity. Thus, some factors associated with obesity are also related to energy balance, but with some specific characteristics with regard to intake (unbalanced diet) and age (adolescence).

In men, a low intake of energy was inversely associated with both overweight and obesity. Being a non-drinker is solely associated with obesity. Abstaining from drinking could be the result of a medical recommendation, although it has been shown that light to moderate alcohol consumption has a favourable effect on the metabolic syndrome[36]. Alternatively, in a north Mediterranean region, not drinking wine might indicate either a different cultural origin or difficulty in socialising. Being single is associated with obesity whereas it is inversely associated with overweight. Some difficulties in everyday life with possible difficult social integration and/or the psychological repercussions of being single may favour the development of obesity. Alternatively, being a non-drinker and single might confound an unbalanced diet (wine drinkers had a better diet quality index than did non-drinkers in our region[11]) or these two factors might reflect a consequence of being obese and not a determinant. Thus although it is shown that diet and energy imbalance might play a role in obesity development, it should be underlined that there are probably other factors that could not be identified in this study, such as specific psychological behaviours and genetics.

There are two types of limitation that could bias our results on obesity prevalence: one is related to the representativeness of the sample, the other to the behaviour of obese subjects. The small number of positive answers might have selected out underweight or normal-weight subjects. The sample was compared with regard to sex and residency distribution with that given by the national institute of statistics (INSEE) for the region under study and found to be similar. Concerning occupational status, the proportions of employees, blue- and white-collar workers and executives in the study sample were also similar to those given by INSEE, but there were fewer manual workers in our study sample than in the general population of the region under study. Therefore, since it is generally known that obesity is more prevalent in this social class, the under-representation of manual workers in our sample may bias the estimation of obesity prevalence. However, this socio-economic class, as well as the low education class, weighted enough to show that it was associated with overweight in our study. Another limitation related to the representativeness of the sample might result from the use of the electoral list for randomisation, since some people may not be registered. However, young people are generally those who are not registered and since only subjects 30 years old and above were included in the study, this bias is minimised. In addition, the inclusion of more young subjects would have lowered the overweight and obesity prevalence, which is not the actual concern. On the other hand, obese subjects could have cheated on their weight. A question on clothes size in the questionnaire permitted us to double-check the validity of the self-declared weight: the correlation between BMI and clothes size of the subjects was 0.82. Overweight and obese subjects could have cheated on both weight and clothes size, but it required two deliberate falsifications in front of a feminine interviewer, which seems less likely.

The major strength of our study is the large coverage of sociodemographic and dietary factors elicited by a validated questionnaire that has been used in several published studies[8–11,13–15] and administered through trained interviewers. Another interesting aspect is the high prevalence of overweight subjects in the sample, mainly in men, which conferred robustness to the findings related to it.

In conclusion, this study suggests that energy imbalance induced by various lifestyle factors plays a major role in the development of overweight whereas obesity represents a more complex entity. Thus, from the perspective of public health policy, it appears useful to (1) develop quantitative and qualitative knowledge about nutrition in the general population, (2) facilitate the development of inexpensive food of good nutritional quality (e.g. processed food, breeding farms for fish) and (3) develop and enhance access to leisure physical activity and sport, especially for adult women. On an individual level, it appears necessary to adapt counselling and recommendations to overweight and obesity, respectively, and in each category also to age, gender, marital status, lifestyle (smoking, drinking, dietary habits, physical exercise) and economic/psychological status.

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Appendix A – Values of coefficients on the axes and square cosines of the correspondence factorial analysis (women)

	Dimension 1			Dimension 2		
	+	−	$\cos^2$	+	−	$\cos^2$
Overweight	0.27		0.97			
Obesity	0.18		0.52	0.17		0.48
occ1	0.65		0.79		−0.33	0.21
oc2	0.28		0.93			
a1		−0.26	0.99			
a2	0.26		0.99			
hrt1	0.25		0.94			
mnp1	0.25		0.99			
mnp2		−0.23	0.99			
sm		−0.22	0.91			
men1	0.22		0.75	0.13		0.25
occ0	0.22		0.58	0.19		0.42
e1	0.22		0.98			
oc1		−0.20	0.93			
e2		−0.17	0.98			
occ2		−0.15	0.98			
wpa2		−0.12	0.96			
p2	0.12		0.91			
k3	0.10		0.86			
lpa1			0.17	0.10		0.83
lpa2			0.17		−0.10	0.83

Appendix B – Values of coefficients on the axes and square cosines of the correspondence factorial analysis (men)

	Dimension 1			Dimension 2		
	+	−	$\cos^2$	+	−	$\cos^2$
Obesity	0.22		0.47	0.23		0.53
Overweight	0.09		0.85			
m1		−0.33	0.91	0.10		0.09
k2		−0.19	0.75		−0.11	0.25
exsm	0.18		0.98			
a1		−0.15	0.90			
a2	0.17		0.90			
e1	0.14		0.96			
nsm		−0.13	0.97			
e2		−0.13	0.96			
occ1	0.13		0.77			
CHO2		−0.11	1.00			
CHO1	0.11		1.00			
nd				0.38		1.00