

Sociodemographic risk factors associated with metabolic syndrome in a Mediterranean population

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Abstract

Objective: To investigate the sociodemographic risk factors associated with metabolic syndrome (MetS) in the Mediterranean population of Catalonia, Spain.

Design and setting: Data from the cross-sectional, population-based 2002–2003 Health Survey of Catalonia were analysed. The survey used a structured questionnaire to collect information on demographics, lifestyle and medical history. In a sub-sample of the original survey population anthropometrics and blood pressure were measured and blood samples were taken to determine HDL cholesterol, TAG and fasting glucose.

Subjects: The analysis included the 1104 individuals aged 18–74 years from this sub-sample who had complete information on all variables necessary to define MetS using the National Cholesterol Education Program's Adult Treatment Panel III (ATP III) and the International Diabetes Federation (IDF) criteria.

Results: MetS prevalence was 28.5% and 24.8% according to IDF and ATP III criteria, respectively. MetS was significantly ($P=0.05$) more common in males than females. MetS prevalence increased significantly ($P<0.001$) with age and degree of adiposity and as social class decreased. In general, MetS prevalence decreased as physical activity increased, which was significant ($P=0.0253$) when applying ATP III criteria. After taking into account important confounders, MetS prevalence was significantly positively associated with male gender, age, BMI, physical inactivity and lower social class. Smoking status, marital status and working situation were not independently associated with MetS.

Conclusions: Age, sex, degree of adiposity, physical activity and social class are the sociodemographic risk factors independently associated with MetS in this Mediterranean population. Understanding which factors predict MetS is important considering likely increasing MetS trends, and is useful for determining public health strategies.

Keywords
Metabolic syndrome
Sociodemographic risk factors
Mediterranean population

The term metabolic syndrome (MetS) describes a clustering of risk factors for CVD. MetS is characterised by the presence of insulin resistance, atherosclerotic dyslipidaemia, hypertension and abdominal obesity^(1,2), and is associated with an increased risk of atherosclerotic disease and a greater incidence of cardiovascular events, type 2 diabetes and total mortality^(3,4). In developed countries MetS is a common condition, prevalent in about 25% of the population^(5–7), although it has been reported to be almost as high in certain developing countries as well^(8,9). There is some evidence that MetS has become more prevalent over the last decade^(5,10,11), probably

influenced in part by increases in obesity, and this will worsen the public health burden of MetS-related morbidity and mortality.

The aetiology of MetS, although not entirely understood, is considered to reside in a complex interaction between genetic, metabolic and environmental factors^(12,13). Understanding what factors are predictive of MetS and how these risk factors are distributed and interrelated within different populations is important for identifying and targeting populations at risk, thus helping in the development and implementation of public health interventions. Previous epidemiological studies in American,

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Asian and European populations have documented an increased prevalence of MetS in men, older age groups, overweight/obese and physically inactive individuals, lower social classes, smokers and certain ethnic groups^(10,14–17). However, because Mediterranean populations have low CVD mortality and increased total longevity^(18–20), it is also of interest to analyse if the predictive risk factors of MetS in these populations remain the same.

There is considerable evidence that the traditional Mediterranean dietary pattern (MDP) is one of the life-style traits protective against many of the cardiovascular risk factors used to define MetS, including improvements in insulin resistance, lipid profile, hypertensive status and degree of adiposity or abdominal obesity^(21–26). Along with these benefits, adherence to a traditional MDP has also been associated with improvements in endothelial dysfunction, oxidation and vascular inflammation^(24,27,28), thereby modifying the risk of MetS^(29,30). In fact, the MDP has been reported to be inversely associated with overall MetS prevalence⁽³¹⁾ and incidence⁽²³⁾ in Mediterranean populations.

To the best of our knowledge, no study to date has explored how sociodemographic risk factors of MetS are distributed and interrelated in a representative sample of a specifically Mediterranean population, whose dietary pattern is protective against MetS. Therefore, the aim of the present study was to examine the sociodemographic risk factors of MetS in a Mediterranean population (Catalonia, Spain), defining MetS using the National Cholesterol Education Program's Adult Treatment Panel III (ATP III) and the International Diabetes Federation (IDF) criteria.

Participants and methods

The study involved an analysis of cross-sectional data from the Health Survey of Catalonia in 2002–2003. This survey was carried out on a random sample of the population of Catalonia and included a representative sample of civilian non-institutionalised adults. The Ethical Committee of the Department of Health of the Catalan Government approved the survey, and all participants gave fully informed written consent.

The survey methodology has been detailed elsewhere⁽³²⁾ and summarised in our previous study, which used the same data to investigate MetS trends in the last 10 years⁽¹¹⁾. In brief, after the initial survey, participants (aged 18–75 years) were invited to undergo an additional clinical examination. The sex and age of the individuals who accepted were comparable to the individuals from the initial samples^(32,33). A structured survey was used to collect information on each individual's sociodemographic characteristics, medical history and other health markers. The clinical health examination involved a physical examination, anthropometric and blood pressure measurements, and biochemical analysis in blood and urine samples.

MetS was defined by both ATP III and IDF definitions^(1,34). ATP III defines an individual as having MetS if three or more of the following five diagnostic criteria are present: (i) waist circumference ≥ 102 cm in men and ≥ 88 cm in women; (ii) hypertriglycerolaemia, TAG ≥ 150 mg/dl (1.695 mmol/l) or use of antihypertriglycerolaemic medication; (iii) low HDL-cholesterol (HDL-C), HDL-C < 40 mg/dl (0.9 mmol/l) in men and < 50 mg/dl (1.1 mmol/l) in women or use of medication to reduce cholesterol; (iv) hypertension, blood pressure $\geq 130/85$ mmHg or use of antihypertensive medication; and (v) hyperglycaemia, fasting glucose ≥ 100 mg/dl (≥ 6.1 mmol/l) or use of antihyperglycaemic medication. The IDF definition is similar but the abdominal obesity cut-off values are lower (≥ 94 cm for European men and ≥ 80 cm for European women), abdominal obesity is a conditional component of the MetS and individuals are also classed as hyperglycaemic if they have previously been diagnosed with type 2 diabetes. Information available on diabetes, medication for hypertension, low HDL-C and hyperglycaemia was self-reported. Medication use for hypertriglycerolaemia was not included in the definition, as information was not collected for this variable. Data from 1104 individuals were available for the analysis, after excluding individuals from the sub-sample with incomplete information on metabolic abnormalities used to define MetS.

The STATA statistical software package version 9.1 (Stata Corp, College Station, TX, USA) was used to analyse MetS prevalence according to sociodemographic characteristics (age, sex, marital status, working situation and social class) and potentially modifiable lifestyle characteristics (BMI, physical activity level and smoking status). BMI was categorised using standard cut-offs⁽³⁵⁾. The odds ratios of MetS according to the characteristics studied were calculated using multiple logistic regression analyses. The two lowest age groups (18–24 and 25–34 years) were combined and used as the reference subgroup, as no significant difference in odds was seen between them in the single-factor logistic regression analysis. Interactions between the risk factors were explored by applying the likelihood ratio test.

Results

A total of 1104 individuals were included in the analysis sample, ranging from 18 to 74 years old (mean 44.9 (SD 15.1) years), of whom 56.1% (n 619) were women. The general characteristics of the sample are presented in Table 1. The global prevalence of MetS according to IDF criteria was 28.5% (95% CI 25.9, 31.2%), and according to ATP III criteria was 24.8% (95% CI 22.3, 27.4%). Table 2 shows the results of the single-factor logistic regression analysis for the prevalence of MetS according to sociodemographic characteristics, applying ATP III and IDF criteria.

Table 1 Characteristics of the study population: sub-sample of individuals aged 18–74 years from the 2002–2003 Health Survey of Catalonia

Baseline characteristic	Women (<i>n</i> 619)		Men (<i>n</i> 485)		Total population (<i>n</i> 1104)	
	Mean or <i>n</i>	SD or %	Mean or <i>n</i>	SD or %	Mean or <i>n</i>	SD or %
Age (years)	44.2	15.2	45.9	14.8	44.9	15.1
Current smokers	166	27.0	182	38.2	348	31.9
BMI (kg/m ²)	25.9	4.9	26.8	3.9	26.3	4.5
BMI ≥ 25 kg/m ²	312	51.8	318	67.0	630	58.5
BMI ≥ 30 kg/m ²	122	20.3	87	18.3	209	19.4
Waist circumference (cm)	82.3	12.7	92.7	11.0	86.9	13.1
Diabetic	30	4.9	37	7.6	67	6.1
Medication for diabetes	19	3.1	26	5.4	45	4.1
Hypertensive*	245	39.6	245	50.5	490	44.3
Medication for hypertension	59	9.6	64	13.2	123	11.2
Hypertriglycerolaemia*	52	8.4	99	20.4	152	13.7
Low HDL cholesterol*	210	33.9	171	35.3	381	34.5
Medication for hypercholesterolaemia	40	6.5	29	6.0	69	6.3
MetS, ATP III criteria	140	22.6	134	27.6	274	24.8
MetS, IDF criteria	162	26.2	153	31.6	315	28.5

MetS, metabolic syndrome; ATP III, National Cholesterol Education Program Adult Treatment Panel III; IDF, International Diabetes Foundation.

*Defined using cut-offs within ATP III and IDF definitions/includes individuals taking medication for this medical condition.

Table 3 presents the results of the multiple logistic regression models, giving the likelihood of having MetS (for both definitions) for age, sex, BMI, physical activity and social class. Working situation, marital status and smoking did not enter the final model as they were not found to be independently associated with MetS; the likelihood ratio test of the difference between models including and excluding these variables separately was not significant, indicating they were not major confounders.

MetS was more prevalent in older compared with younger age groups (Table 2). Only 2.5% of individuals aged 18–24 years had MetS (both criteria), whereas 59.7% (IDF criteria) and 51.1% (ATP III criteria) of 65–74-year-olds had MetS, with a significant trend ($P < 0.001$) for an increase in MetS with age. In addition, the presence of four or all five of the MetS criteria increased with age (results not shown). In the multiple variable logistic regression analysis (Table 3), age was independently associated with risk of having MetS after controlling for important confounders; 65–74-year-olds were 12.9 times (IDF criteria) or 11.1 times (ATP III criteria) more likely to have MetS compared with 18–34-year-olds (P for trend < 0.001).

MetS was significantly less common in females than in males, using both MetS definitions (Table 2); applying IDF criteria 31.6% of males had MetS compared with 26.2% of females ($P = 0.050$). This gender effect remained after adjusting for important confounders (Table 3). When applying ATP III criteria females were 40% ($P = 0.010$) less likely to have MetS than males. However, when applying IDF criteria, although females were 30% less likely to have MetS than males, this did not reach a level of statistical significance ($P = 0.084$).

As expected, the prevalence of MetS increased ($P < 0.001$) with BMI in the single factor analysis applying

both definitions (Table 2). Over 60% of obese individuals had MetS, compared with about 5% of normal-weight individuals. In addition, the presence of four or all five of the MetS criteria increased with BMI and almost no normal-weight individuals had more than three MetS components (results not shown). BMI was also independently associated with the risk of having MetS after controlling for important confounders (Table 3). Obese individuals were 22.0 times (IDF criteria) and 16.4 times (ATP III criteria) more likely to have MetS than normal-weight individuals (P for trend < 0.001).

MetS prevalence tended to decrease when physical activity increased in the single factor analysis (Table 2). After adjusting for important confounders, the effect of exercise only became apparent in the active group, who had a 50% lower risk of having MetS than the inactive group (Table 3). However, the trend of decreasing MetS risk with increasing physical activity was significant only when applying ATP III criteria (P for trend = 0.054).

MetS was most prevalent in individuals from lower social classes and decreased gradually as social class increased ($P < 0.001$). Over 30% of individuals from low social class had MetS, while MetS was present in 16.8% (ATP III criteria) and 19.6% (IDF criteria) of individuals from high social class (Table 2). Social class was also independently associated with risk of MetS (Table 3), but the effect reached significance only in the low social class group, who were 2.0 (95% CI 1.1, 3.7) and 1.9 (95% CI 1.1, 3.5) times more likely to have MetS than the high social class group, when applying ATP III and IDF criteria respectively.

Applying both ATP III and IDF criteria, MetS was most prevalent in past smokers (Table 2). In relation to marital and working status, MetS was most common in individuals who were married/living together and in retired individuals.

Table 2 The prevalence of MetS according to sociodemographic characteristics, applying ATP III and IDF criteria: sub-sample of individuals aged 18–74 years from the 2002–2003 Health Survey of Catalonia

Variable	Subjects		MetS, ATP III criteria			MetS, IDF criteria		
	<i>n</i>	%	≥3 (%)*	95 % CI	<i>P</i> for trend	≥3 (%)*	95 % CI	<i>P</i> for trend
Total	1104	100	24.8	22.3, 27.4	N/A	28.5	25.9, 31.2	N/A
Sex	1104							
Women	619	56.1	22.6	19.3, 25.9	0.056	26.2	22.7, 29.6	0.050
Men	485	43.9	27.6	23.6, 31.6		31.6	27.4, 35.7	
Age (years)	1104							
18–24	118	10.7	2.5	0.3, 5.4	<0.001	2.5	0.3, 5.4	<0.001
25–34	190	17.2	7.4	3.6, 11.1		9.0	4.9, 13.0	
35–44	238	21.6	14.7	10.2, 19.2		19.8	14.7, 24.8	
45–54	235	21.3	29.8	23.9, 35.7		32.3	26.3, 38.4	
55–64	184	16.7	44.0	36.8, 51.3		48.4	41.1, 55.7	
65–74	139	12.6	51.1	42.7, 59.5		59.7	51.5, 68.0	
Marital status	1100							
Married/couple	795	72.3	29.7	26.5, 32.9	N/A	33.5	30.2, 36.7	N/A
Single	238	21.6	8.0	4.5, 11.5		11.3	7.3, 15.4	
Other†	67	6.1	28.4	17.3, 39.4		29.9	18.6, 41.1	
Working situation	1103							
Working	616	55.9	19.3	16.2, 22.4	N/A	22.9	19.6, 26.2	N/A
Housewife/husband	190	17.2	34.7	27.9, 41.6		37.4	30.4, 44.3	
Unemployed	81	7.3	19.8	10.9, 28.6		19.8	10.9, 28.6	
Retired	156	14.1	44.9	37.0, 52.8		51.9	44.0, 59.9	
Other	60	5.4	5.0	0.6, 10.7		8.3	1.1, 15.5	
Social class	1068							
Low	202	18.9	31.7	25.2, 38.1	<0.001	35.2	28.5, 41.8	<0.001
Middle	368	34.5	25.8	21.3, 30.3		29.1	24.4, 33.7	
High to middle	284	26.6	24.3	19.3, 29.3		28.5	23.3, 33.8	
High	214	20.0	16.8	11.8, 21.9		19.6	14.3, 25.0	
BMI‡	1077							
Normal	447	41.4	5.4	3.3, 7.5	<0.001	5.6	3.5, 7.7	<0.001
Overweight	421	39.1	28.3	23.9, 32.6		35.2	30.6, 39.7	
Obese	209	19.4	60.3	53.6, 67.0		64.1	57.6, 70.7	
Physical activity	1066							
Inactive	192	18.0	26.0	19.8, 32.3	0.025	28.1	21.7, 34.5	0.193
Moderately inactive	176	16.5	31.3	24.3, 38.1		30.7	23.8, 37.6	
Moderately active	543	51.0	24.7	21.0, 28.3		29.8	26.0, 33.7	
Very active & active	155	14.5	16.1	10.3, 22.0		19.4	13.1, 25.6	
Smoking status	1091							
Current (daily)	318	29.2	19.5	15.1, 23.9	0.012	21.4	16.9, 25.9	<0.001
Current (occasional)	30	2.8	13.3	0.4, 26.2		13.3	0.4, 26.2	
Past	165	15.1	31.5	24.4, 38.7		35.8	28.4, 43.1	
Never	578	29.1	26.5	22.9, 30.1		31.3	27.5, 35.1	

MetS, metabolic syndrome; ATP III, National Cholesterol Education Program Adult Treatment Panel III; IDF, International Diabetes Foundation; N/A, not applicable.

*Row percentage.

†Widowed or divorced.

‡Normal weight, BMI = 18.5–24.9 kg/m²; overweight, BMI = 25.0–29.9 kg/m²; obese, BMI ≥ 30.0 kg/m².

Discussion

To the best of our knowledge, this is the first cross-sectional study to describe the sociodemographic risk factors that are related to MetS in a representative sample from a Mediterranean adult population, applying two commonly used criteria to define MetS (from the ATP III panel and IDF). The results show that MetS was independently associated with age, sex, BMI, physical activity and social class. MetS was defined by both ATP III and IDF criteria because the two definitions gave reasonably different estimates of the global prevalence of MetS in this population⁽¹¹⁾. The IDF definition predicted a higher prevalence of MetS (classifying an additional group of individuals with MetS), which could have altered the risk

factors associated with MetS between the two definitions. However, the results showed that the two definitions predicted similar risk factors for MetS, although the relationships between sex and physical activity and MetS were weaker when applying the IDF criteria.

As expected, age was an independent risk factor of MetS, which is a consistent finding in large studies^(10,15). Previous research on MetS in this population found that the prevalence of each of the components of MetS increased with age⁽¹¹⁾. A number of explanatory diet- and lifestyle-related risk factors are likely to be involved, affecting weight and multiple metabolic abnormalities and explaining the life course development of MetS.

The protective effect of female gender on risk of MetS found in our study has also been reported in a study of a

Table 3 Odds ratios of MetS according to sociodemographic risk factors, applying ATP III and IDF criteria: sub-sample of individuals aged 18–74 years from the 2002–2003 Health Survey of Catalonia

Demographic risk factor	MetS, ATP III criteria			MetS, IDF criteria		
	OR	95% CI	<i>P</i> for trend	OR	95% CI	<i>P</i> for trend
Age (years)						
18–34	1.0	referent		1.0	referent	
35–44	2.1	1.1, 4.2		2.5	1.3, 4.8	
45–54	5.2	2.7, 9.9		4.4	2.4, 8.1	
55–64	7.1	3.7, 13.6		6.0	3.2, 11.1	
65–74	11.1	5.6, 22.1	<0.001	12.9	6.6, 25.1	<0.001
Sex						
Male	1.0	referent		1.0	referent	
Female	0.6	0.4, 0.9	0.010	0.7	0.5, 1.0	0.084
BMI*						
Normal	1.0	referent		1.0	referent	
Overweight	4.3	2.6, 7.0		6.4	3.9, 10.5	
Obese	16.4	9.6, 28.1	<0.001	22.0	12.7, 38.1	<0.001
Physical activity						
Inactive	1.0	referent		1.0	referent	
Moderately inactive	1.3	0.7, 2.4		1.0	0.5, 1.8	
Moderately active	1.1	0.7, 1.7		1.2	0.8, 1.9	
Very active & active	0.5	0.2, 0.9	0.054	0.5	0.3, 1.0	0.361
Social class						
High	2.0	1.1, 3.7	0.005	1.9	1.1, 3.5	0.013
High to middle	1.5	0.9, 2.6		1.4	0.8, 2.4	
Middle	1.1	0.6, 1.9		1.1	0.7, 1.9	
Low	1.0	referent		1.0	referent	

MetS, metabolic syndrome; ATP III, National Cholesterol Education Program Adult Treatment Panel III; IDF, International Diabetes Foundation. Models adjusted for age, sex, BMI, physical activity and social class.

*Normal weight, BMI = 18.5–24.9 kg/m²; overweight, BMI = 25.0–29.9 kg/m²; obese, BMI ≥ 30.0 kg/m².

Spanish working population⁽³⁶⁾ and in other non-Mediterranean populations^(14,37). It is likely to be a reflection of the clinical finding that men experience CVD and related complications around 10 years earlier than women, whose risk increases more after menopause. It has long been hypothesised that the protective effect of oestrogen is involved, although the exact mechanisms behind this theory are still being investigated⁽³⁸⁾.

Individuals were much more likely to have MetS if they were overweight or obese; nearly two-thirds of obese individuals had MetS, which is high and comparable to that observed in obese men in a US sample⁽¹²⁾. As abdominal obesity is a major determinant of MetS⁽³⁹⁾, it is not surprising that being overweight/obese was a strong predictor of MetS prevalence in our study, which is consistent with previous research^(12,14,40). Nevertheless, BMI and abdominal obesity are not identical in terms of their pathophysiological role in MetS. When individuals with the same BMI and age but different body fat distributions are compared, those with central body fat have a greater risk of insulin resistance⁽⁴¹⁾. The specific role of abdominal obesity and visceral fat compared with gluteofemoral obesity in the aetiology of MetS has been attributed to differences in processes such as lipolysis, lipogenesis, fatty acid uptake, and secretion and expression of hormones and inflammatory factors⁽⁴²⁾.

As in other Western societies, there are increasing trends in overweight/obesity in Catalonia (although obesity increased only in males and not females)⁽⁴³⁾, which may be related in part to the documented deviation

from the traditional MDP⁽³³⁾. Moreover, there is also evidence that MetS prevalence is increasing in this region⁽¹¹⁾. Whether greater adherence to the MDP within overweight/obese individuals in this population has a protective effect against MetS and related metabolic abnormalities remains to be investigated.

Higher levels of physical activity were independently associated with reduced risk of MetS, which is probably due to its effect on lipid profiles, insulin resistance, overweight/obesity status and other related risk factors⁽¹⁶⁾. The differences in the ATP III and IDF criteria resulted in 11.1% of individuals being classified discordantly as with or without MetS⁽¹¹⁾. This discrepancy may help explain why the protective effects of physical activity on MetS risk differed between the definitions (the effect was stronger and significant only when ATP III criteria were applied).

Social class was a strong independent risk factor for having MetS, which has been replicated in previous research on social class or related factors such as education level and household income^(12,36). For instance, a study of an active Spanish working population⁽³⁶⁾ reported that manual labourers were significantly more likely to have MetS than managers and office workers. This increased risk is likely to be mediated through differences in dietary habits, such as adherence to the MDP, and other lifestyle characteristics between social classes, which could subsequently affect weight, lipid profiles, blood pressure and glucose levels.

The main limitation of the present study is its cross-sectional design, which implies that the relationships

between sociodemographic characteristics and MetS described should not be taken as causal. A further methodological issue is that the health survey was not specifically designed to explore the risk factors associated with MetS, and therefore some of the subgroups were very small, limiting the study's power to test for interactions. MetS was also defined without information on medication use for hypertriglycerolaemia which forms part of the ATP III and IDF definition (as the survey did not collect this information). However, this is unlikely to influence the results, as information on TAG levels was available and the population was probably unable to distinguish between medication use for triacylglycerolaemia and that for hypercholesterolaemia.

In conclusion, it is clear that there are important risk factors associated with having MetS in this Mediterranean population, as MetS was positively associated with age, male gender, BMI, physical inactivity and lower social status. Although these risk factors are similar to those found in non-Mediterranean populations, it is important to identify and assess them considering that MetS is high and becoming more prevalent in this population. In addition, Mediterranean populations are a distinctive study group because their traditional dietary pattern is protective against many cardiovascular risk factors that define MetS. Expanding our knowledge to give a better understanding of the relationship between socio-demographic risk factors for MetS should help when formulating public health strategies.

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