Increase in metabolic syndrome as defined by ATPIII from 1992–1993 to 2002–2003 in a Mediterranean population

Genevieve G Buckland, Jordi Salas-Salvadó, Lluís Serra-Majem, Conxa Castell, Juanjo Cabré, and Lluis Salleras-Sanmartí

This paper presents the results of a study that aimed to describe the prevalence and evolution of metabolic syndrome (MetS) in the Mediterranean population of Catalonia, Spain, between 1992–1993 and 2002–2003 by applying the National Cholesterol Education Program's Adult Treatment Panel III (ATPIII) and International Diabetes Federation (IDF) definitions. Data from two cross-sectional population-based surveys were used (ENCAT 1992–1993 [n = 820] and 2002–2003 [n = 1,384]). Applying IDF definitions, MetS tended to increase (P = 0.08), from 25% in 1992–1993 to 28.5% in 2002–2003. Applying ATPIII definitions, MetS prevalence was lower, and it increased significantly (P < 0.001) from 18.4% in 1992–1993 to 24.8% in 2002–2003. MetS prevalence is high and has increased significantly in the last decade in Catalonia.

INTRODUCTION

Metabolic syndrome (MetS) is a cluster of metabolic abnormalities that leads to an increased risk of type 2 diabetes mellitus (T2D),[1,2] cardiovascular disease (CVD),[3,4] and all-cause mortality.[5] Abdominal obesity and insulin resistance have been proposed as the central key causative factors of this syndrome.[6,7,8] The cluster of cardiovascular risk factors increases the risk of CVD and T2D over and above the risk of each metabolic abnormality.[9] In addition, the severity of coronary disease and its complications correlate with the number of MetS components each individual possesses.[1,10,11]

In the last decade, several definitions of MetS have been proposed by several expert groups, such as the National Cholesterol Education Program's Adult Treatment Panel III (ATPIII)[1] and the International Diabetes Federation (IDF),[9] who have recently proposed that their updated definitions serve as a universally accepted diagnostic tool. Using these definitions, estimates of the prevalence of MetS in different populations suggest that approximately 20–25% of adults in developed countries have MetS.[9]

The prevalence of MetS is expected to rise in parallel with obesity[1] and therefore to have significant implications on public health. However, there is limited

Affiliations: *GG Buckland* is with the Human Nutrition Unit, Hospital Universitari de Sant Joan, IISPV Universitat Rovira i Virgili, Reus, Spain, and the Unit of Nutrition, Environment and Cancer, Cancer Epidemiology Research Programme, Catalan Institute of Oncology, Barcelona, Spain. *J Salas-Salvadó* is with the Human Nutrition Unit, Hospital Universitari de Sant Joan, IISPV Universitat Rovira i Virgili, Reus, Spain, and CIBER 06/03, Fistopatología de la Obesidad y Nutrición, Instituto de Salud Carlos III, Madrid, Spain. *L Serra-Majem* is with the Department of Clinical Sciences, University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain, and the Community Nutrition Research Center, University of Barcelona Science Park, Barcelona, Spain. *C Castell* is with the Division of Public Health, Health Department, Generalitat de Catalunya, Barcelona, Spain. *J Cabré* is with the Human Nutrition Unit, Hospital Universitari de Sant Joan, Departament de Bioquímica i Biotecnologia, Facultat de Medicina i Ciències de la Salut, Universitat Rovira i Virgili, Reus, Spain, and the Centre d'Asistència Primaria Sant Pere, Servei Català de la Salut, Reus, Spain. *L Salleras-Sanmartí* is with the Department of Public Health, School of Medicine, University of Barcelona, Barcelona, Spain.

Correspondence: *J Salas-Salvadó*, Unitat de Nutrició Humana, Facultat de Medicina i Ciències de la Salut, C/Sant Llorenç-21, 43201 Reus, Spain. E-mail: jordi.salas@urv.cat, Phone: +34-977-759-313, Fax: +34-977-759-322.

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information on trends in MetS, as only a handful of studies have been carried out.[12,13,14] Although the prevalence of MetS has been studied in several Mediterranean populations,[15,16,17,18,19] to our knowledge, trends in MetS have not.

Consequently, we aimed to study a population from an important Mediterranean area (Catalonia, Spain) and to examine changes in the prevalence of MetS and the individual metabolic abnormalities of MetS between the periods 1992–1993 and 2002–2003, using ATPIII and IDF definitions.

MATERIALS AND METHODS

Survey methodology and subjects

Data from two separate cross-sectional nutrition surveys, the Nutritional Survey of Catalonia in 1992–1993 (ENCAT 1992–1993) and in 2002–2003 (ENCAT 2002–2003) were used in the analysis. They both included a representative sample of the civilian noninstitutionalized adult population of Catalonia and were approved by the Ethical Committee of the Department of Health of the Catalan Government. All subjects who participated in the surveys provided fully informed written consent. Full methodological details have been described previously for both ENCAT 1992–1993[20] and ENCAT 2002–2003.[21,22]

In both surveys, individuals from the initial sample aged between 18 and 75 years were asked to participate in an additional clinical examination. This resulted in a subsample of 820 individuals in ENCAT 1992–1993 and 1,374 individuals in ENCAT 2002–2003 who agreed to undergo this examination and whose data are used in the study. These individuals were similar to those from the initial selected samples in terms of age and sex.[20,21,22]

Data collection

Both surveys used a detailed structured questionnaire to quantify demographics, lifestyle, diet, medical history, use of medication, and other data on markers of health for each participant. In ENCAT 1992–1993, only individuals who were previously diagnosed with T2D were asked about their use of medication for diabetes. The detailed clinical health examination, carried out on the subsample selected from both surveys, included a physical examination, anthropometrical and blood pressure measurements, and a laboratory analysis of blood and urine samples. Weight, height, waist, and hip circumference were measured and body mass index (BMI) calculated. Blood pressure was taken twice, in accordance with the American Society of Hypertension protocol. An average of the two results was used for the statistical analysis. Blood samples were taken under fasting conditions to provide biochemical information.

Diagnosis of metabolic syndrome

MetS was defined by both ATPIII and IDF definitions.[1,9] According to ATPIII, an individual has MetS if three or more of the following five diagnostic criteria are present: 1) waist circumference ≥102 cm in men and ≥88 cm in women; 2) hypertriglyceridemia: ≥150 mg/dL (1.695 mmol/L) or on medication for hypertriglyceridemia; 3) low high-density lipoprotein (HDL) cholesterol: <40 mg/dL (0.9 mmol/L) in men and <50 mg/dL (1.1 mmol/L) in women or on medication for reduced cholesterol; 4) hypertension: ≥130/85 mmHg or on antihypertensive medication; or, 5) hyperglycemia: ≥100 mg/dL (≥6.1 mmol/L) or on drug treatment for elevated glucose. A similar definition is outlined by the IDF. However, the cutoff values used for central obesity are lower (≥94 cm for European men and ≥80 cm for European women), and central obesity is a conditional component of MetS. Individuals are also classed as hyperglycemic if they have previously been diagnosed with T2D.

Diabetes, medication for hypertension, hypercholesterolemia, and hyperglycemia were self-reported. There were no specific questions about the use of medication for hypertriglyceridemia, so this was not included in these definitions. Only those individuals whose data were complete for all the metabolic abnormalities of MetS were used to estimate the prevalence, resulting in 1,104 individuals for ENCAT 2002–2003.

Statistical analysis

All analyses were carried out using the Stata 9.1 software (Stata Corp, College Station Texas, USA). Prevalence data was presented as percentages with 95% confidence intervals (95% CI). The statistical differences between characteristics within and between the samples were evaluated using chi-square tests. Differences between the characteristics were considered significant at $P < 0.05$. The Mantel-Haenszel test for trend was carried out to assess the association between the prevalence of MetS and age. Age adjustment was carried out using the population structure of Catalonia in 2003 as the reference.[23] Kappa statistics[24] were used to assess interdefinition concordance on the prevalence of MetS. We examined MetS prevalence using individuals' characteristics, including age, sex, marital status, BMI, physical activity level, smoking status, working situation, and social class. BMI was categorized using standard cutoff values.[25]

RESULTS

Description of study population

ENCAT 1992–2003 contained 820 individuals between 18 and 74 years of age (mean age, 45.6 years ± [SD] 16.9), of whom 461 (56.2%) were women (Table 1). ENCAT 2002–2003 included 1,374 individuals between 18 and 74 years of age (mean age, 45.3 ± 15.1 years), of whom 768 (55.9%) were women. Although the prevalence of overweight was similar between the groups, the prevalence of obesity increased between 1992–1993 (14.5%) and 2002–2003 (19.2%).

Table 1 **Characteristics of the study population in the periods 1992–1993 and 2002–2003.**

Characteristic	1992–1993		2002–2003	
	N		*N*	
	n	%	*n*	%
Total	820		1,374	
Gender	820		1,374	
Women	461	56.2	768	55.9
Men	359	43.8	606	44.1
Age (years)	820		1,374	
18–24	130	15.9	138	10.0
25–34	126	15.4	240	17.5
35–44	171	20.9	285	20.7
45–54	92	11.2	299	21.8
55–64	179	21.8	232	16.9
65–74	122	14.9	180	13.1
Marital status	820		1,370	
Married/couple	538	65.6	1,001	73.1
Single	224	27.3	285	20.8
Other	58	7.1	84	6.13
Working status	820		1,373	
Working	407	49.6	750	54.6
Housewife/husband	151	18.4	239	17.4
Unemployed	49	6.0	109	7.9
Retired/disabled	147	17.9	206	15.0
Other	66	8.1	69	5.0
Social class	798		1,347	
Low	269	33.7	251	18.6
Medium	340	42.6	966	71.7
High	189	23.7	251	18.6
BMI	816		1,348	
Underweight (≤18.4)	10	1.2	15	1.1
Normal weight (18.5–24.9)	381	47.9	551	40.9
Overweight (25–29.9)	307	37.6	523	38.8
Obese (≥30)	118	14.5	259	19.2
Physical activity level	802		1,327	
Sedentary	462	57.6	461	34.7
Moderately active	238	29.68	802	60.4
Active	102	12.7	64	4.8
Smoking status	817		1,356	
Never	427	52.3	726	53.5
Past	145	17.8	201	14.8
Current	245	30.0	429	31.6

Abbreviations: BMI, body mass index.

Prevalence of metabolic syndrome

In 1992–1993, the overall prevalence of MetS was 18.4% (95% CI 15.8–21.1%) when ATPIII criteria were used and even higher (25%; 95% CI 22.0–28.0%) when IDF criteria were used (Table 2). The fact that the confidence intervals do not overlap suggests that the definitions give significantly different prevalence estimates. No significant differences between men and women were observed in the prevalence of MetS in 1992–1993 ($P = 0.48$ with ATPIII and $P = 0.715$ with IDF criteria). In 2002–2003, the overall prevalence of MetS was 24.8% (95% CI 22.3–27.4%) when ATPIII criteria were used and 28.5% (95% CI 25.9–31.2%) when IDF criteria were used. The two definitions do not give significantly different prevalence estimates as the two confidence intervals overlap. As in 1992–1993, MetS prevalence in 2002–2003 tended to be higher in men than in women. However, these differences were significant when IDF criteria were used ($P = 0.05$). MetS prevalence increased with age ($P < 0.001$) in both time periods and for both definitions (Figure 1A,B). Over half of the individuals in the oldest age group (65–74 years) had MetS in 2002–2003 (51.1% with ATPIII criteria and 59.7% with IDF criteria).

Changes in the prevalence of metabolic syndrome between 1992–1993 and 2002–2003

In the 10-year period from 1992–1993 to 2002–2003, the prevalence of MetS – when ATPIII criteria were used – increased significantly ($P < 0.001$) by 6.4% (from 18.4% to 24.8%) (Table 2). The increase in MetS from 1992–1993 to 2002–2003 when IDF criteria were used was slightly less at 3.5% (25% to 28.5%), and was not significant ($P = 0.08$). In alignment with this, the 95% CI for MetS prevalence in 1992–1993 and 2002–2003 did not overlap when ATPIII criteria were used, but it did overlap when IDF criteria were used. The increases in the prevalence of MetS were greater in men than in women for both definitions, but were only significant for men ($P = 0.006$) and women (0.042) when ATPIII criteria were used. The increases in MetS from 1992–1993 to 2002–2003 were not even across the age groups, and the youngest age group of 25–34 years exhibited the greatest increases (925%), from 0.8% (95% CI 0.0–2.3%) in 1992–1993 to 7.4% (95% CI 3.6–11.1%) in 2002–2003 (ATPIII criteria).

The age-adjusted prevalence of MetS was slightly lower in both time periods for both definitions. However, the pattern was very similar. With ATPIII criteria, the prevalence of MetS was 16.04% (95% CI 13.7–18.4%) in

Table 2 **Prevalence of metabolic syndrome overall and by gender in the periods 1992–1993 and 2002–2003.**

Population	Using ATPIII definition				Using IDF definition				Agreement	
	No. meeting criteria/*n*	Percent with MetS	(95% CI)	*P* (x^2)	No. meeting criteria/*n*	Percent with MetS	(95% CI)	*P* (x^2)	% ± SE	Strength of agreement*†
1992–2003										
Total	151/820	18.4	(15.8–21.1)		205/820	25.0	(22.0–28.0)		90 ± 0.03	Good
Women	81/461	17.6	(14.1–21.1)	0.480	113/461	24.5	(20.6–28.5)	0.715	92.6 ± 0.05	Good
Men	70/359	19.5	(15.4–23.6)		92/359	25.6	(21.1–30.2)		86.6 ± 0.05	Good
2002–2003										
Total	274/1,104	24.8	(22.3–27.4)		315/1,104	28.5	(25.9–31.2)		88.9 ± 0.03	Good
Women	140/619	22.6	(19.3–25.9)	0.056	162/619	26.2	(22.7–29.6)	0.050	93.2 ± 0.04	Very good
Men	134/485	27.6	(23.6–31.6)		153/485	31.6	(27.4–35.7)		83.3 ± 0.05	Moderate
Difference between time periods	Percent difference (95% CI)	*t*-test (*P*)	Percent increase		Percent difference (95% CI)	*t*-test (*P*)	Percent increase			
Total	6.40 (2.7–10.1)	<0.001	34.7		3.50 (−0.5–7.5)	0.08	14.0			
Women	5.00 (0.39.8)	0.042	28.4		1.70 (−3.6–6.9)	0.536	6.9			
Men	8.10 (2.4–13.8)	0.006	8.10		6.00 (−0.2–12)	0.06	23.4			

* All *P* value significant at <0.001.

† Kappa test, Landis and Koch (1977).[24]

Abbreviations: ATPIII, Adult Treatment Panel III; CI, confidence interval; IDF, International Diabetes Federation; MetS, metabolic syndrome; SE, standard error.

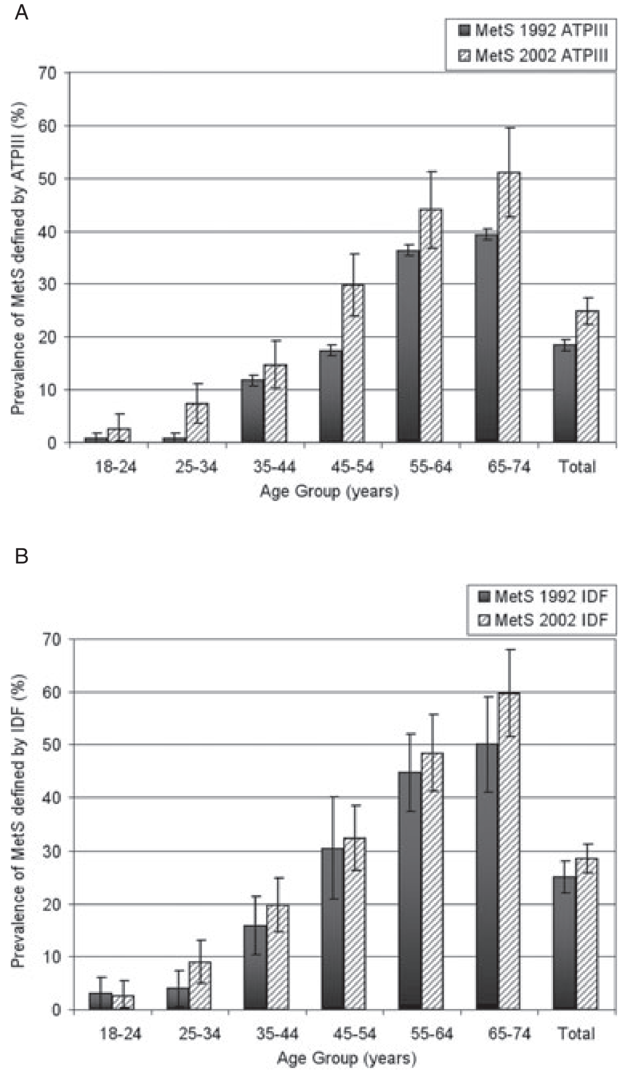

Figure 1 **Increases in the prevalence of metabolic syndrome (MetS) between 1992–1993 and 2002–2003 in Catalonia, Spain, applying ATPIII (1A) and IDF (1B) criteria. Increases are especially pronounced in the younger age groups.**

1992–1993 and increased to 23.2% (95% CI 21.0–25.5%) in 2002–2003. With IDF criteria, MetS prevalence was 22.8% (95% CI 20.1–25.5%) in 1992–1993 and increased to 26.9% (95% CI 24.5–29.3%) in 2002–2003.

Agreement between ATPIII and IDF definitions

In terms of classifying the same individuals with or without MetS, ATPIII and IDF definitions classified 90% ($P < 0.001$) of the individuals concordantly in 1992–1993 and 88.9% ($P < 0.001$) in 2002–2003 (Table 2).

Prevalence of each component of metabolic syndrome

Table 3 outlines the prevalence of each of the five components of MetS. The most common components for

Table 3 **Prevalence of each of the five components of metabolic syndrome in the periods 1992–1993 and 2002–2003.**

Criteria for defining metabolic syndrome[†]	1992–1993							2002–2003						
	Total ($n = 820$)		Women		Men			Total ($n = 1,374$)		Women		Men		
	%	No. meeting criteria/*n*	Gender differences					%	No. meeting criteria/*n*	Gender differences				
			%	*n*	%	*n*	*P**			%	*n*	%	*n*	*P**
Abdominal obesity (IDF) (≥94 cm [m], ≥80 cm [w])	47.7	391/820	52.3	241/461	41.8	150/359	0.003	50.4	574/1,139	54.4	348/499	45.3	226/499	0.002
Abdominal obesity (ATPIII) (≥102 cm [m], ≥88 cm [w])	24.4	200/820	30.6	141/461	16.4	59/359	<0.001	26.3	299/1,139	32.3	207/640	18.4	92/499	<0.001
Hypertriglyceridemia (≥150 mg/dL)	17.6	144/820	14.1	65/461	22.0	79/359	0.003	14.3	185/1,293	8.5	61/720	21.6	124/573	<0.001
Low HDLc (<40 mg/dL [m], <50 mg/dL [w]) &/or medication use	21.3	175/820	23.2	107/461	18.9	68/359	0.139	32.5	447/1,374	31.6	243/768	33.7	204/606	0.427
Hypertension (≥130 SBP or ≥85 DBP mmHg) &/or medication use	47.8	392/820	43.6	201/461	53.2	191/359	0.006	45.3	622/1,374	40.0	307/768	52.0	315/606	<0.001
Hyperglycemia (≥100 mg/dL) &/or type II diabetes (IDF)	30.5	250/820	25.0	115/461	37.6	135/359	<0.001	38.7	532/1,374	32.4	249/768	46.7	283/606	<0.001
Hyperglycemia (≥100 mg/dL) &/or medication use (ATPIII)	30.2	248/820	24.3	112/461	37.9	136/359	<0.001	38.6	530/1,374	32.4	249/768	46.4	281/606	<0.001

* *P* values calculated using chi-square test for gender differences.

[†] Criteria for abdominal obesity and elevated glucose differ for ATPIII and IDF.

Abbreviations: ATPIII, Adult Treatment Panel III; DBP, diastolic blood pressure; HDLc, high-density lipoprotein cholesterol; IDF, International Diabetes Federation; SBP, systolic blood pressure.

both sexes (in both time periods) were abdominal obesity, hypertension, and hyperglycemia. In 1992–1993, about a quarter of the sample (24.4%) were classified as abdominally obese by ATPIII criteria and about half (47.7%) by IDF criteria. In 2002–2003, abdominal obesity increased to 26.3% with ATPIII criteria and 50.4% with IDF criteria. The prevalence of hypertension was very high in both 1992–1993 (47.8%) and 2002–2003 (45.3%). Hypertriglyceridemia was the least common condition in both surveys.

All of the components of MetS except for abdominal obesity were more common in men than in women in both time periods (Table 3). There was strong evidence ($P < 0.01$ or less) of these gender differences in the prevalence of the components of MetS except for low HDL cholesterol levels. Between 1992–1993 and 2002–2003 there was a dramatic increase in the prevalence of low HDL cholesterol in men as well as decreases in the prevalence of hypertriglyceridemia and hypertension, especially in women. More individuals had at least one of the components of MetS (IDF definition) in 2002–2003 (78.2%) than in 1992–1993 (75%). In both time periods there was also a steady increase in the prevalence of each of the components of MetS with age (Figure 2A,B).

DISCUSSION

The present study shows that, in this Mediterranean adult population, around a quarter of the adults have MetS, and the prevalence of MetS increased significantly between 1992–1993 and 2002–2003, according to ATPIII criteria. These increases were especially pronounced in men and in the younger age groups. This adds to the handful of other studies on MetS trends and reveals that even in a Mediterranean population, where the prevalence of chronic diseases is often lower than in other Westernized populations, the prevalence of MetS is both high and increasing.

In 2002–2003, the application of ATPIII criteria showed MetS prevalence to be 24.8% (23.2% after age adjustment), which is nearly identical to the rates observed in the Canary Islands, Spain (24.4%),[15] Greece (24.5%),[16] and the United States (23.9%)[26] when the same criteria were applied. The number of individuals labeled as having MetS increased substantially to 28.5% (26.9% after age adjustment) when IDF criteria were used. The current prevalence of MetS is likely to be even higher if trends have continued on the same path indicated in this study. The fact that the prevalence of MetS was higher with IDF criteria than with ATPIII criteria is also consistent with other studies[16,27] and is due to the lower abdominal obesity cutoff points for IDF criteria, which lead to more individuals being defined as abdominally obese and, consequently, as having MetS.

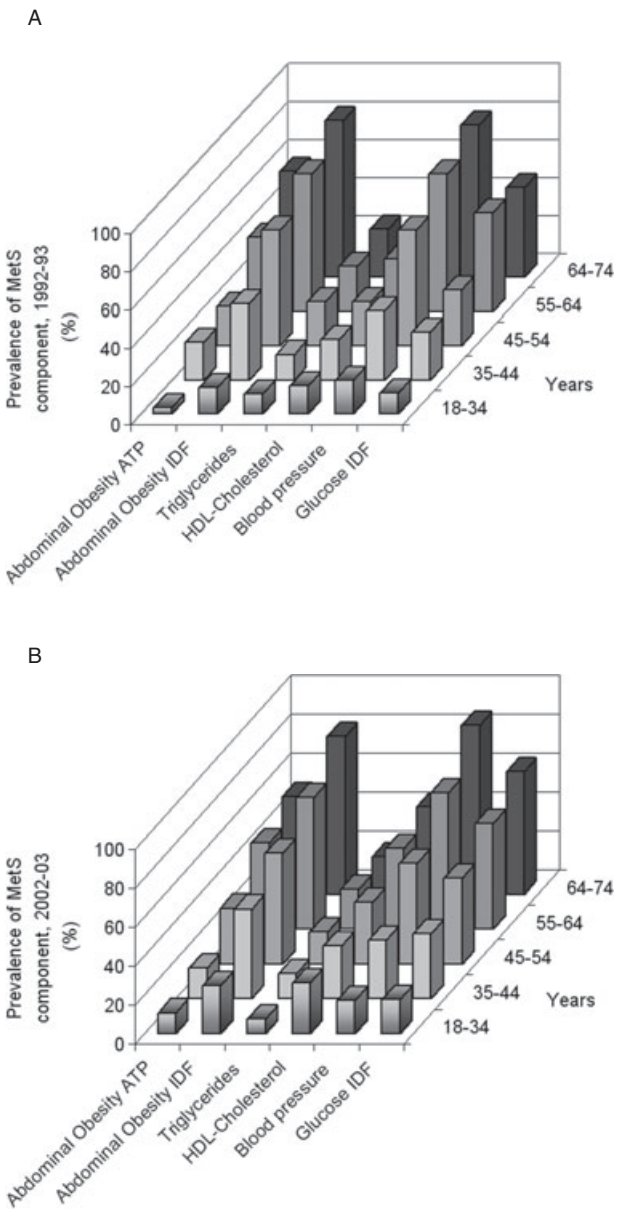

Figure 2 **Age-related increases in each component used to define metabolic syndrome (MetS), as observed in 1992–1993 (1A) and 2002–2003 (1B).**

Interestingly, the increase in the prevalence of MetS over this 10-year period was actually lower with IDF than with ATPIII criteria. As abdominal obesity is a fixed component in IDF criteria, individuals with three or more of the remaining components who are not abdominal obese may be excluded, but the same individuals will be included under the ATPIII definition. Therefore, greater increases over time in these other four components of MetS would explain why MetS increases more when ATPIII criteria are used. Despite these differences, the two definitions classified a high percentage of the participants equally (around 90%) and with a good strength of agree-

ment, which was higher in women than in men during both time periods. Other studies observed a similar finding.[26,27] The most suitable definition and abdominal obesity cutoff points to apply to this Mediterranean population depend on which definition best predicts CVD and T2D, which is an area for future research.

Between 1992–1993 and 2002–2003, the prevalence of MetS increased from 18.4% to 24.8%, which is similar to the increase reported in the United States, also using ATPIII criteria and a similar time period.[13] The increases in MetS in Catalonia cannot be explained by shifts in demographics towards an aging population, because the age-adjusted prevalence, although lower, showed similar increases and was significant when the ATPIII criteria were used. In Catalonia, the prevalence of overweight and obesity increased substantially from 1989 to 2002, and currently 39% of the population are overweight and 17% are obese.[28] Our study also revealed increases in the prevalence of abdominal obesity in both men and women during the 10-year period. Therefore, as with the United States and other Westernized populations,[1,29] the increasing trends in obesity over the last decade are likely to be a major contributor to these increasing trends in MetS in Catalonia. This will add to both the burden of CVD, the leading cause of death in Spain,[30] and T2D; in fact, Spain is projected to have the tenth highest increase in the world for the prevalence of T2D in 2025.[31]

Abdominal obesity and hypertension were the most common components of MetS in the present study. This has also been observed in previous studies.[15,32] Women had a significantly higher prevalence of abdominal obesity than men, which is consistent with findings in the United States[32] and the Canary Islands.[15] This is perhaps surprising since increases in obesity over the past decade have been far more pronounced in men than in women (by 1997 overweight and obesity increased to 34.8% in males and 25.6% in females).[33] One possible explanation is that the women in this population were more predisposed to gaining abdominal weight. In general, however, the components of MetS were significantly more common in males; this pattern is similar to that of two other studies in Spain.[15,34]

In 2002–2003, fewer individuals had none of the components of MetS and more individuals had all five components than in 1992–1993, which highlights the overall increasing prevalence of these metabolic abnormalities within this population. However, there were distinct variations in the trends of each MetS component: the prevalence of abdominal obesity, low HDL cholesterol, and hyperglycemia increased and the prevalence of hypertension and hypertriglyceridemia decreased slightly. Interestingly, this is exactly the same pattern as the changes seen in Mexico City between 1990–1992 and 1997–1999.[12] These trends are likely to be a partial reflection of the nutrition transition occurring in Spain, with a shift towards a more "unhealthy" Westernized diet. This has led to decreases in the ratio of monounsaturated and polyunsaturated/saturated fat,[35] which would have a negative effect on population lipid profiles and obesity. Moreover, in the Spanish diet a large proportion of energy (42%) is derived from carbohydrates,[36] which, when refined, have a high glycemic index that contributes to increasing levels of hyperglycemia, hyperinsulinism, and obesity. Furthermore, although the proportion of the Spanish population that is totally sedentary in their leisure time has decreased slightly over the last decade, it is still very high, at 45%.[36] Together, sedentary lifestyles, nutrition transitions, and subsequent increases in obesity help explain the increases in metabolic disorders and abdominal obesity in this population.

In the present study, there were gender variations in the degree that MetS prevalence increased, with men experiencing greater and more significant increases than women. This has also been observed in other populations[14] and may be explained by the more pronounced increase in male obesity.

Our observation that MetS prevalence increases with age is a unanimous finding.[14,32] In 2002–2003, nearly half of the population aged 55–64 years had MetS, which is a very high prevalence and represents a considerable public health concern due to the substantial increases in morbidity and mortality caused by MetS. The life-course development of this syndrome is illustrated in this study by the steady increase in the prevalence of each metabolic abnormality with age. MetS is not only becoming more common in general, it is becoming especially more common in young adults (20- to 30-year-olds). As increases in obesity are particularly pronounced in children and adolescents, the prevalence of metabolic abnormalities and MetS is likely to increase in younger adults as well.[29]

Our study has several limitations. MetS was defined without taking into account hypertriglyceridemia medication according to ATPIII and IDF criteria, as neither of the surveys specifically asked for this information. However, as information for a partial component of only one criterion was not available, it is unlikely that this significantly underestimates the prevalence of MetS. In addition, selection bias may be present in our study, because individuals who agreed to the health examination may not be completely representative of the population who undertook the initial nutrition survey questionnaire, although they were representative in age and sex. In addition, the study analyzes data from two different groups of individuals (two independent cross-sectional samples from the same population), 10 years apart. Therefore, the conclusions about increases in MetS prevalence over this

time period are limited by its cross-sectional design and should be interpreted tentatively.

CONCLUSION

In conclusion, these cross-sectional studies of representative samples of a Mediterranean population suggest that the prevalence of MetS is increasing and is present in around a quarter of adults when evaluated according to ATPIII criteria and in nearly a third when evaluated according to IDF criteria. These increasing trends in MetS are probably due to concurrent rises in overweight and obesity, particularly in younger age groups. The aging population would also contribute to increases in MetS, which further adds to the burden of CVD and T2D in Catalonia. These findings give further evidence to support the need for comprehensive public health lifestyle interventions that address both diet and physical activity and the obesogenic environment underlying these issues.

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Declaration of interest. The authors have no interests to declare.

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