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ORIGINAL ARTICLE

# Metabolic syndrome and socioeconomic status in France: The French Nutrition and Health Survey (ENNS, 2006–2007)

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**Abstract**
*Objectives* The main objective was to estimate, in France, the prevalence of metabolic syndrome (MetS) and to investigate the association between socioeconomic position and MetS.
*Methods* The French National Nutrition and Health Survey (ENNS) cross-sectional national multistage sampling was carried out in 2006–2007. Data collection included waist circumference and blood pressure measurements, blood sample and sociodemographic and medication information. The prevalence of MetS was assessed using several definitions, including Joint Interim Statement (JIS). Association with sociodemographic covariates was assessed using logistic regression models.
*Results* Among the 1,856 participants 18–74 years of age, MetS prevalence was found to vary from 14.6 % (*National Cholesterol Education Program* definition) to 21.1 % (JIS), with no difference between genders. After adjustment, risk of MetS increased with age in both men and women. In women, MetS risk was inversely associated with education level. Risk of MetS was higher in men born outside France than in French-born males.
*Conclusions* MetS prevalence appeared to be lower in France than in most industrialised countries. The promoting of public health measures to reduce MetS, for example, lifestyle changes, is of utmost importance, particularly among less favourable socioeconomic categories and among migrants.

**Keywords** Metabolic syndrome · Socioeconomic status · Prevalence · Prevention · Adults · National

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## Introduction

Metabolic syndrome (MetS) is a cluster of metabolic disorders that include central obesity, dyslipidaemia, high blood pressure (BP) and increased fasting plasma glucose (FPG). It has been found to be associated with increased risk of cardiovascular diseases (CVD), type 2 mellitus diabetes and all-cause mortality (Ford 2005; Grundy 2008; Mottillo et al. 2010) independently of other CVD risk factors (Gami et al. 2007). Along with age, overweight and obesity constitute major forces underlying Mets (Grundy 2008). In France, as elsewhere, the increasing prevalence of obesity observed over the last decade is assumed to contribute to the rise of MetS prevalence. This prevalence remains unknown; indeed, previous estimates were based

mainly on regional samples that differed according to recruitment method, age category and the MetS definition used (Balkau et al. 2007; Dallongeville et al. 2005).

Among earlier surveys, some reported an inverse association between socioeconomic position and MetS (Park et al. 2003; Scuteri et al. 2008), particularly in women. Individuals with lower socioeconomic status had increased risk of obesity, dyslipidaemia, hypertension, insulin resistance and MetS. Socioeconomic position is assumed to influence lifestyle, i.e. unhealthy dietary habits, sedentary lifestyle, smoking and excessive alcohol consumption, which in turn modify MetS risk (Dallongeville et al. 2005). To more effectively target and improve primary preventive measures, particularly lifestyle changes, coordination of public health policies and early identification, it is useful to identify individuals at higher risk of MetS, such as those with a less favourable socio-economic status.

The French Nutrition and Health Survey (ENNS) was carried out in 2006–2007 on a large national sample of children 3–17 years of age, and adults aged 18–74, to describe food intake, physical activity and nutritional status in France (Castetbon et al. 2009). The main purposes of the analyses presented here were to estimate MetS prevalence in adults aged 18–74 and to describe the association between socioeconomic position and the MetS risk.

## Methods

The French Nutrition and Health Survey was a cross-sectional descriptive survey conducted from February 2006 to July 2007, based on a multistage stratified random sample of the population living in mainland France (excluding the island of Corsica and French overseas territories). The study design included a food consumption survey and a health examination in adults. The theoretical sample size of the food consumption survey was based on EFCOSUM recommendations (Brussaard et al. 2002), advocating at least 2,000 individuals so as to describe dietary intake at the country level. Sampling and study methods are described in detail elsewhere (Castetbon et al. 2009). Briefly, sample selection was based on a three-stage cluster design, stratified by region and degree of urbanisation (four groups, from "rural" to "towns of more than 100,000 inhabitants"). At the first stage, 190 geographic zones (municipalities or groups of municipalities) were randomly selected. The second stage involved random selection of households based on randomly generated phone lists; households that had a landline (with or without a freely listed phone number) or cell phones only. The third stage of sampling involved selection of eligible participants for inclusion in the study.

The survey was carried out according to the Declaration of Helsinki guidelines. All participants gave written informed consent and the survey protocol received the approval of the Ethical Committee (Hôpital Cochin no. 2264), the Consultative Committee on Information Treatment of the Ministry of Research and the French Data Protection Authority (Commission nationale de l'informatique et des libertés, CNIL, authorisation no. 905481).

### Data collection

The health examination survey included measurement of waist circumference (WC) and BP by trained nurses, carried out at a health examination centre of the French National Health Insurance System (Caisse nationale d'assurance maladie des travailleurs salariés, Cnam-TS) or at home. WC was measured according to World Health Organisation guidelines (de Onis and Habicht 1996) using flexible plastic fibre tape placed at the midpoint between the lower rib margin and the iliac crest. A run of three measurements of blood pressure was realised (device OMRON© M5-I), at 1-min intervals after a 5-min rest. A second run of three measurements was carried out when the second and third measurements differed by more than 10 mmHg. The average of the last two readings of SBP and DBP was computed for the analysis. If only one BP measurement was available, that recording was considered as the average. Fasting (at least 12 h) venous blood was drawn in fluorine or iodo-acetate tubes, and stored in frozen containers (4 °C) for less than 4 h before analysis at the laboratories of the health examination centres, all of which participated in a national quality control program. All measurements were performed according to a standardised protocol and using the same devices (automated Olympus®). FPG was assayed by the hexokinase method applied to a colorimetric measurement. Total cholesterol, high density lipoprotein cholesterol (HDL-c) and triglyceride (TG) levels were measured using an enzymatic colorimetric method.

### Sociodemographic data and current medication

Sociodemographic data were collected at home by trained dieticians using a face-to-face standardised questionnaire developed by the French National Institute of Statistics and Economic Studies (INSEE). Data collected included birthplace (France and French overseas territories, or elsewhere), marital status (married or living with a partner, single, separated, divorced or widowed), occupation (management/intermediate profession, self-employed/farmers, manual workers/employees, homemakers, disabled persons and others), education level (university, high school, secondary or primary school) and frequency of holiday trips (lasting at least four nights) during the past 12 months, shown in previous studies to be strongly associated with low household income (Le Jeannic and Ribera 2006). Participants reporting no such holiday trips

were considered as belonging to the low income category. Current medication was noted using a self-administered questionnaire and controlled by medication packaging and physician's prescriptions during the home visit. Drugs were classified according to the Anatomic Therapeutic Chemical (ATC) classification system. ATC groups included in this analysis were: C02 (antiadrenergic agents), C03 (diuretics), C07 (beta-blocking agents), C08 (calcium channel blockers), C09 (agents affecting the renin-angiotensin system), A10 (antidiabetics including oral medication and injected insulin) and C10AB (fibrates, the most commonly used TG-lowering medication and HDL-c raising medication).

## MetS definitions

Prevalence of MetS and its diagnostic criteria were calculated according to the *National Cholesterol Education Program Adult Treatment Panel III* (NCEP/ATP III) definition (Expert Panel on Detection Evaluation and Treatment of High Blood Cholesterol in Adults 2001), the American Heart Association (AHA) and the National Heart, Lung, and Blood Institute (NHLBI) definition (Grundy et al. 2005), the International Diabetes Federation (IDF) definition (Alberti et al. 2005) and the recent Joint Interim Statement (JIS) definition (Alberti et al. 2009). The different thresholds corresponding to the four MetS definitions for WC, FPG, TG, HDL-c and BP abnormalities are shown in Table 1. The NCEP/ATP III definition has been adapted to take into account lipid-lowering, BP-lowering and antidiabetic drugs.

To assess MetS prevalence, participants who reported current use of fibrates along with normal TG and HDL-c blood concentrations were considered as having a TG abnormality.

## Statistical analysis

Due to participation bias, data were weighted for each gender according to national census data on age, diplomas and presence of at least one child in the household. To take into account seasonality, final weighting also included the season of health examination.

Prevalence of MetS and its components were calculated with a confidence interval of 95 % (95 % CI) across gender and age categories. Associations between socioeconomic covariates (birthplace, marital status, occupation, education and holiday trip during the past 12 months) and MetS probabilities were investigated using univariable and multiple regression models. Due to interactions between gender and socioeconomic factors such as birthplace ($p = 0.015$), occupation ($p = 0.008$) and education ($p < 10^{-3}$), regression analyses were performed separately for men and women. All statistical analyses were carried out using the survey commands of STATA® V.10 (Stata Corporation, College Station, TX, USA), to take into account the complex sample scheme. Significance was taken as $p < 0.05$.

There is increasing evidence that unhealthy lifestyle behaviour is influenced by socioeconomic status (Park and Kang 2008) and increases the risk of Mets, such behaviour includes physical inactivity (Laaksonen et al. 2002) and

**Table 1** Criteria determining Metabolic Syndrome as defined by: the National Cholesterol Education Program/Adult Treatment Panel III (Expert Panel on Detection Evaluation and Treatment of High Blood Cholesterol in Adults, 2001), the American Heart Association / National Heart Lung and Blood Institute (Grundy et al., 2005), the International Diabetes Federation (Alberti et al., 2005) and the Joint Interim Statement (Alberti et al., 2009)

| | NCEP/ATP III‡ (2001) | AHA/NHLBI (2005) | IDF (2005) | JIS (2009) |
|---|---|---|---|---|
| | **Any three or more of:** | **Any three or more of:** | **Mandatory elevated WC** | **Any three or more of:** |
| Elevated WC | ≥ 102 cm (men) or ≥ 88 cm (women) | ≥ 102 cm (men) or ≥ 88 cm (women) | ≥ 94* cm (men)<br>≥ 80* cm (women) | ≥ 94* cm (men)<br>≥ 80* cm (women) |
| | | | **Plus two or more of:** | |
| Elevated FPG | ≥ 6.1 mmol/l or antidiabetic medication | ≥ 5.6 mmol/l or antidiabetic medication | ≥ 5.6 mmol/l or antidiabetic medication | ≥ 5.6 mmol/l or antidiabetic medication |
| Elevated Triglycerides | ≥ 1.7 mmol/l or medication for elevated TG§ | ≥ 1.7 mmol/l or medication for elevated TG§ | ≥ 1.7 mmol/l or medication for elevated TG§ | ≥ 1.7 mmol/l or medication for elevated TG§ |
| Reduced HDL-c | < 1.03 mmol/l (men) or < 1.29 mmol/l (women) or medication for reduced HDL-c§ | < 1.03 mmol/l (men) or < 1.29 mmol/l (women) or medication for reduced HDL-c§ | < 1.03 mmol/l (men) or < 1.29 mmol/l (women) or medication for reduced HDL-c§ | < 1.03 mmol/l (men) or < 1.29 mmol/l (women) or medication for reduced HDL-c§ |
| Elevated BP | ≥130/85 mmHg or BP-lowering medication | ≥130/85 mmHg or BP-lowering medication | ≥130/85 mmHg or BP-lowering medication | ≥130/85 mmHg or BP-lowering medication |

‡ Adapted to take into account lipid-lowering, BP-lowering medication and antidiabetic drugs

* Europid references

§ In the present analyses, we considered fibrates to be the most commonly used drugs for elevated TG and reduced HDL-c

smoking (Sun et al. 2012). However, since such factors may be part of the causal pathway between socioeconomic status and risk of MetS, we did not include lifestyle in logistic regression models so as to avoid potential over-adjustment and to capture the overall association of SES on the MetS risk (Au and Hollingsworth 2011).

## Results

A total of 2,102 of the 3,115 adults included in the ENNS diet survey (participation rate: 59.7 %) (Castetbon et al. 2009) underwent anthropometric and BP measurements and a blood test (overall response rate: 40.3 %). Pregnant women ($n = 19$) and adults with incomplete clinical or sociodemographic data ($n = 246$) were excluded from the present analyses, which were thus carried out on 1,856 participants (707 men and 1,149 women). For 41 % of them, anthropometric and BP measurements were performed at home. For both men and women, no differences were found in mean SBP and DBP adjusted for age according to the place where measurements were carried out (data not tabulated).

Compared to the French general population (Table 2), participants included in our analyses were more likely to be older, to belong to the managerial/intermediate

**Table 2** Sociodemographic characteristics of the 1,856 adults aged 18–74 years with complete data, compared to national census data

| | Raw data | | Weighted[a] data | | Census |
|---|---|---|---|---|---|
| | Men | Women | Men | Women | Data |
| Age (%) in years | | | | | |
| 18–29 | 12.0 | 20.1 | 21.4 | 20.2 | 22.0 |
| 30–54 | 51.8 | 56.0 | 51.0 | 49.8 | 49.7 |
| 55–74 | 36.2 | 33.9 | 27.6 | 30.0 | 28.3 |
| Birthplace (%) | | | | | |
| France | 89.8 | 90.6 | 90.6 | 91.1 | 87.9 |
| Outside | 10.2 | 9.4 | 9.4 | 8.9 | 12.1 |
| Marital status (%) | | | | | |
| Married/living with a partner | 74.3 | 70.4 | 72.7 | 73.7 | 88.9[b] |
| Single | 16.4 | 12.0 | 22.3 | 14.9 | |
| Separated/divorced/widowed | 9.3 | 17.6 | 5.0 | 11.4 | 11.1 |
| At least one child at home (%) | | | | | |
| Yes | 35.1 | 41.4 | 34.8 | 34.0 | 35.7 |
| No | 64.9 | 58.6 | 65.2 | 66.0 | 64.3 |
| Occupation (%) | | | | | |
| Management/intermediate profession | 32.4 | 25.8 | 22.3 | 16.4 | 20.2 |
| Self-employed/farmers | 6.5 | 2.9 | 6.2 | 2.3 | 5.2 |
| Manual workers/employees | 28.7 | 33.2 | 40.0 | 39.4 | 33.1 |
| Retired | 26.2 | 22.3 | 21.5 | 20.4 | 24.1 |
| Homemakers, disabled persons, others | 6.2 | 15.9 | 10.0 | 21.5 | 17.4 |
| Education level (%) | | | | | |
| University | 38.0 | 35.0 | 20.7 | 20.1 | 19.8 |
| High school | 19.7 | 18.5 | 18.7 | 16.5 | 17.2 |
| Secondary school | 33.2 | 33.8 | 52.1 | 40.0 | 42.5 |
| Primary school | 9.1 | 12.8 | 18.4 | 23.5 | 20.5 |
| Holiday trip during the past 12 months (%) (as a proxy of household income) | | | | | |
| Yes | 73.8 | 73.3 | 68.6 | 68.6 | 64.6[c] |
| No | 26.2 | 26.7 | 31.4 | 31.4 | 35.4[c] |

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[a] Weighting accounted for multilevel sampling design and for calibration according to national census data (age, education level, household including at least one child or not)

[b] Including single

[c] 15–79 years

occupational category and to have a higher education level. However, after calibration, the weighted socio-demographic characteristics of the sample were similar to those of the general population for the selected variables.

## Prevalence of diagnostic criteria for MetS

Among men, elevated BP was the most common metabolic abnormality (Table 3). In women, high BP was the most frequent diagnostic criterion for MetS using NCEP/ATP III and AHA/NHLBI definitions, whereas increased WC was most common according to IDF and JIS definitions.

Prevalences of MetS components, except for high WC and low HDL-c, were significantly higher in men than in women (Table 3). Elevated WC was significantly more common in women than in men whatever the MetS definition, whereas no difference in reduced HDL-c was observed according to gender. Prevalences of elevated WC ($p < 10^{-3}$), elevated TG ($p = 0.03$), elevated BP ($p < 10^{-3}$) and elevated FPG ($p < 10^{-3}$) significantly increased with age in both men and women (data not tabulated).

## Prevalence of MetS

Among adults aged 18–74 living in France, the MetS prevalence was 14.1 % (12.5–16.9), 16.6 % (14.4–19.0), 20.3 % (18.0–22.9) and 21.1 % (18.7–23.7) according to NCEP/ATP III, AHA/NHLBI, IDF and JIS definitions, respectively. No significant difference in MetS prevalence was observed between genders whatever the definition used or the age (Table 4). In both men and women, risk of MetS dramatically increased with age for all MetS definitions.

## Association with sociodemographic factors

After adjustment for age, MetS prevalence according to the JIS definition decreased with a higher education level in women, but not in men (Table 5). Among women with the lowest education level, the risk of MetS was approximately fivefold higher than in women with a university education. The prevalence of IDF MetS was also significantly higher among women who did not take a holiday trip during the past 12 months compared to those who did. The risk of MetS was increased in men born outside of France compared to those born in France (Table 5).

In multiple logistic regression analyses stratified by sex (Table 6), age remained positively associated with risk of MetS in both men [for 1 year: ORa = 1.07, (1.04–1.09), $p < 10^{-3}$] and women [ORa = 1.05, (1.04–1.07), $p < 10^{-3}$]. MetS risk also remained significantly higher in men born outside of France compared to those born in France. Conversely, although not statistically significant, MetS risk tended to be lower in men with the lowest education level [ORa = 0.45, (0.20–1.02), $p = 0.06$] compared to those with the highest education level.

In women, education level was still inversely associated with MetS risk. Compared to women with the highest education level, women with the lowest education level faced a sixfold greater risk of MetS, whereas the association with holiday trips was no longer significant. For both men and women, the same pattern of associations was

**Table 3** Prevalences of diagnostic criteria for metabolic syndrome according to sex in French 18–74-year-old adults ($n = 1{,}856$)

| | Men | | Women | | $p$ (men vs women) |
|---|---|---|---|---|---|
| | Weighted % | 95 % CI | Weighted % | 95 % CI | |
| Elevated WC | | | | | |
| >102 cm (men) and >88 cm (women) | 19.5 | 15.7–24.0 | 26.5 | 23.2–30.0 | 0.02 |
| ≥102 cm (men) and ≥88 cm (women) | 21.6 | 17.7–26.2 | 29.2 | 25.8–32.9 | 0.01 |
| ≥94 cm (men) and ≥80 cm (women) | 43.5 | 38.4–48.7 | 50.0 | 46.0–54.0 | 0.06 |
| Elevated FPG | | | | | |
| ≥6.1 mmol/l and/or antidiabetic medication | 15.2 | 11.9–19.2 | 7.6 | 5.8–9.8 | $<10^{-3}$ |
| ≥5.6 mmol/l and/or antidiabetic medication | 28.0 | 23.7–32.7 | 16.0 | 13.4–18.9 | $<10^{-3}$ |
| Elevated TG | | | | | |
| ≥1.7 mmol/l and/or fibrate medication | 23.5 | 19.4–28.1 | 16.7 | 13.9–19.9 | 0.01 |
| Reduced HDL-c | | | | | |
| <1.03 mmol/l (men) or <1.29 mmol/l (women) and/or fibrate medication | 18.7 | 14.5–23.7 | 20.4 | 17.3–23.8 | 0.55 |
| Elevated BP | | | | | |
| ≥130/85 mmHg or BP-lowering medication | 49.3 | 44.1–54.5 | 35.8 | 32.2–39.6 | $<10^{-3}$ |

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**Table 4** Prevalence of the metabolic syndrome according to sex and age category using different metabolic syndrome definitions in French 18–74-year-old adults ($n = 1{,}856$)

| | Age (years) | Men | | | Women | | | $p$ (men vs women) |
|---|---|---|---|---|---|---|---|---|
| | | Weighted % | 95 % CI | $P$-trend for age | Weighted % | 95 % CI | $P$-trend for age | |
| MetS definition[a] | | | | | | | | |
| NCEP/ATP III | 18–39 | 4.3 | 1.7–10.8 | | 3.1 | 1.7–5.8 | | |
| | 40–54 | 12.9 | 7.7–20.6 | | 12.9 | 9.2–17.7 | | |
| | 55–74 | 30.0 | 22.9–38.1 | | 25.7 | 20.7–31.4 | | |
| | All | 14.4 | 11.2–18.4 | $<10^{-3}$ | 13.7 | 11.4–16.4 | $<10^{-3}$ | 0.74 |
| AHA/NHLBI | 18–39 | 6.5 | 3.3–12.6 | | 3.2 | 1.7–5.8 | | |
| | 40–54 | 15.5 | 10.0–23.3 | | 14.8 | 10.9–19.7 | | |
| | 55–74 | 34.6 | 27.3–42.8 | | 29.6 | 24.4–35.4 | | |
| | All | 17.5 | 14.0–21.6 | $<10^{-3}$ | 15.7 | 13.2–28.5 | $<10^{-3}$ | 0.43 |
| IDF | 18–39 | 9.1 | 5.2–15.4 | | 5.1 | 2.9–8.9 | | |
| | 40–54 | 19.4 | 13.5–27.0 | | 18.9 | 14.4–24.3 | | |
| | 55–74 | 40.3 | 32.6–48.4 | | 34.4 | 28.8–40.4 | | |
| | All | 21.3 | 17.7–25.6 | $<10^{-3}$ | 19.3 | 16.5–22.4 | $<10^{-3}$ | 0.41 |
| JIS | 18–39 | 9.8 | 5.8–16.0 | | 5.1 | 2.9–8.9 | | |
| | 40–54 | 22.0 | 15.8–29.9 | | 18.9 | 14.4–24.3 | | |
| | 55–74 | 41.1 | 33.4–49.3 | | 34.7 | 29.2–40.7 | | |
| | All | 22.8 | 19.0–27.1 | $<10^{-3}$ | 19.4 | 16.7–22.5 | $<10^{-3}$ | 0.18 |

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[a] Participants who reported current use of fibrates were counted as having hypertriglyceridemia abnormality

**Table 5** Prevalence of the metabolic syndrome (Joint Interim Statement definition) and socioeconomic factors associated with metabolic syndrome in French 18–74-year-old adults ($n = 1{,}856$) after adjustment for age

| | Men | | | | | Women | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Weighted % | 95 % CI | OR | 95 % CI | $p$ | Weighted % | 95 % CI | OR | 95 % CI | $p$ |
| Birthplace | | | | | | | | | | |
| France | 17.5 | 13.7–22.2 | 1.0 | – | – | 15.8 | 12.9–19.2 | 1.0 | – | – |
| Outside | 40.2 | 24.5–58.2 | 3.2 | 1.5–6.8 | 0.01 | 17.0 | 9.6–28.4 | 1.1 | 0.5–2.2 | 0.79 |
| Marital status | | | | | | | | | | |
| Married/living with a partner | 18.5 | 14.4–23.5 | 1.0 | – | – | 16.7 | 13.4–20.5 | 1.0 | – | – |
| Single | 22.8 | 11.0–41.2 | 1.3 | 0.5–3.3 | 0.59 | 12.4 | 6.2–23.2 | 0.7 | 0.3–1.6 | 0.39 |
| Separated/divorced/widowed | 25.2 | 14.3–40.5 | 1.5 | 0.7–3.1 | 0.29 | 14.1 | 9.6–20.1 | 0.8 | 0.5–1.3 | 0.39 |
| Occupation | | | | | | | | | | |
| Management/intermediate profession | 18.7 | 13.6–25.0 | 1.0 | – | – | 14.5 | 10.0–20.4 | 1.0 | – | – |
| Self-employed/farmers | 24.8 | 12.5–43.1 | 1.4 | 0.6–3.5 | 0.42 | 12.0 | 6.0–22.6 | 0.8 | 0.4–1.8 | 0.60 |
| Manual workers/employees | 20.4 | 15.1–27.1 | 1.1 | 0.7–1.8 | 0.65 | 16.3 | 12.9–20.3 | 1.1 | 0.7–1.8 | 0.59 |
| Homemakers, disabled persons, others | 3.3 | 0.4–21.5 | 0.1 | 0.1–1.3 | 0.08 | 21.3 | 11.2–36.6 | 1.6 | 0.6–3.8 | 0.29 |
| Education level | | | | | | | | | | |
| University | 18.6 | 13.7–24.8 | 1.0 | – | – | 4.7 | 3.0–7.3 | 1.0 | – | – |
| High school | 23.4 | 13.3–38.0 | 1.3 | 0.6–2.9 | 0.46 | 15.2 | 9.7–22.9 | 3.6 | 1.8–7.2 | $<10^{-3}$ |
| Secondary school | 22.6 | 16.8–29.6 | 1.3 | 0.8–2.1 | 0.35 | 19.3 | 15.2–24.3 | 4.9 | 2.8–8.5 | $<10^{-3}$ |
| Primary school | 10.3 | 5.4–18.7 | 0.5 | 0.2–1.1 | 0.08 | 20.3 | 13.7–28.9 | 5.2 | 2.7–10.0 | $<10^{-3}$ |
| Holiday trip during the past 12 months (as a proxy of household income) | | | | | | | | | | |
| Yes | 19.3 | 14.9–24.6 | 1.0 | – | – | 13.8 | 10.9–17.4 | 1.0 | – | – |
| No | 20.6 | 13.8–29.5 | 1.1 | 0.6–1.8 | 0.77 | 20.6 | 15.6–26.8 | 1.6 | 1.1–2.4 | 0.02 |

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**Table 6** Socioeconomic factors associated with the risk of metabolic syndrome in French 18–74-year-old adults ($n = 1{,}856$) after adjustment for age

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | ORa | 95 % CI | *p* | ORa | 95 % CI | *p* |
| Birthplace | | | | | | |
| France | 1.0 | – | – | | | |
| Outside | 3.0 | 1.4-6.2 | 0.003 | | | |
| Occupation | | | | | | |
| Management/intermediate profession | 1.0 | – | – | 1.0 | – | – |
| Self-employed/farmers | 1.5 | 0.7–3.2 | 0.26 | 0.4 | 0.2–1.1 | 0.09 |
| Manual workers/employees | 1.3 | 0.8–2.3 | 0.99 | 0.6 | 0.3–1.1 | 0.09 |
| Homemakers, disabled persons, others | 0.2 | 0.02–1.8 | 0.15 | 0.8 | 0.3–2.2 | 0.71 |
| Education level | | | | | | |
| University | 1.0 | – | – | 1.0 | – | – |
| High school | 1.2 | 0.5–2.5 | 0.70 | 4.2 | 1.9–9.0 | $<10^{-3}$ |
| Secondary school | 1.1 | 0.6–2.0 | 0.69 | 6.2 | 3.2–12.0 | $<10^{-3}$ |
| Primary school | 0.5 | 0.2–1.02 | 0.06 | 6.3 | 2.8–14.2 | $<10^{-3}$ |
| Holiday trip during the past 12 months (as a proxy of household income) | | | | | | |
| Yes | | | | 1.0 | – | – |
| No | | | | 1.5 | 0.9–2.2 | 0.09 |

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obtained using the other three MetS definitions (data not tabulated).

## Discussion

The prevalence of MetS among 18–74-year-old French adults varied from 14.1 % according to the NCEP/ATP III definition to 21.1 % according to that of the JIS. Differences between NCEP/ATP III and JIS MetS prevalences arose mainly from cut-off values used for high WC (102/88 and 94/80 cm, respectively) and high FPG (6.1 and 5.6 mmol/l). However, IDF and the JIS definitions led to similar estimates of MetS prevalence. These two definitions use the same thresholds except for elevated WC, a mandatory component of MetS under the IDF definition. The absence of a difference between IDF and JIS MetS prevalences indicates that almost all adults identified as having MetS according to the JIS definition were centrally obese.

Comparison of MetS prevalence across industrialised countries is difficult due to differences in age groups, population recruitment and MetS definitions. Using the JIS definition, MetS prevalence tends to be lower in France than that previously observed in Luxembourg [28 % in 18–69-year-old adults in 2007–2008 (Alkerwi et al. 2011)], Hungary [39 and 31 % in 20–69-year-old men and women, respectively, in 2005, (Szigethy et al. 2012)], Greece [46 % in adults ≥18 years old in 2003–2004 (Athyros et al. 2010)], Lithuania [44 and 49 % in 45–72-year-old men and women, respectively, in 2006–2008 (Luksiene et al. 2011)], Spain [33 % in adults ≥18 years old in 2001–2003 (Gavrila et al. 2011)] and USA [40 % in adults ≥20 years old in 1999–2004 (Alberti et al. 2009)]. The JIS-defined MetS prevalence seems to be close to that observed in Canada [23 % in adults ≥18 years old in 2007–2009 (Riediger and Clara 2011)]. Analysis of the three other MetS definitions leads to the same conclusion: MetS prevalence observed in France is moderate compared to that in other industrialised countries (Grundy 2008; Qiao 2006). These results are consistent with previous surveys reporting better eating habits and healthier attitudes (Pettinger et al. 2006) in France, with only a moderate prevalence of obesity (Vernay et al. 2009), hypertension (Godet-Mardirossian et al. 2012) and type 2 diabetes (Bonaldi et al. 2011) compared to other European countries. This might explain why the French population appears to be less affected by CVD mortality (Muller-Nordhorn et al. 2008) compared to other European countries.

Regardless of the MetS definition used, no statistically significant difference was observed in the prevalence of MetS between men and women in France. These results are in line with those of previous surveys carried out in Norway (Hildrum et al. 2007), the USA (Alberti et al. 2009) and Canada (Riediger and Clara 2011). Nevertheless, several surveys have found a higher prevalence of MetS in men than in women (Alkerwi et al. 2011; Szigethy et al. 2012), while a higher prevalence was found among

Lithuanian women (Luksiene et al. 2011), due to a gender difference in the prevalence of obesity.

As previously reported, and regardless of the definition used, the prevalence of MetS and its metabolic components, except for reduced HDL-c, were highly age-dependent both in men and women. Along with obesity, ageing constitutes the main factor accounting for the current increase in MetS prevalence in industrialised countries (Grundy 2008).

To implement prevention programs promoting lifestyle changes, it is crucial to identify groups at high risk of MetS. Our results showed an inverse association between education level and MetS prevalence in women, but not in men. These results are in line with several previous surveys (Athyros et al. 2010; Dallongeville et al. 2005; Park et al. 2003; Scuteri et al. 2008) reporting an inverse association between socioeconomic position and risk of MetS in women. Previous analyses carried out on the same national sample highlighted an inverse association between socioeconomic status, particularly education level and household income, and overall and central overweight and obesity in women, but not in men (Vernay et al. 2009). Several possible explanations have been proposed, including differences in lifestyle (diet, physical activity and smoking), sensitivity to psychological stress, body image and access to medical care. Reduced leisure time physical activity (Crespo et al. 1999) and high consumption of low-cost energy-dense foods composed of refined grains, added sugars and fat (Darmon and Drewnowski 2008) have been observed in lower socioeconomic categories, partly due to limited financial resources. Several surveys have demonstrated that a healthy diet, for example, the Mediterranean diet, is associated with improvement of endothelial dysfunction, oxidation and vascular inflammation (Fung et al. 2009), thereby preventing MetS. Other surveys have shown that unhealthy lifestyle behaviour, such as physical inactivity (Laaksonen et al. 2002) or smoking (Sun et al. 2012), increases the risk of Mets. A significant inverse association between adherence to French nutritional guidelines (including physical activity) and overall risk of MetS has already been reported among French 18–49-year-old adults (Julia et al. 2010). It has also been found that persons in less favourable socioeconomic categories less frequently followed nutritional recommendations (Malon et al. 2010). Another potential explanation lies in susceptibility to psychological stress, which also varies across socioeconomic categories, and to central adiposity and insulin resistance, particularly in women having a low socioeconomic status (Tentolouris et al. 2006). Differences in body image, and more generally, dietary and health behaviour, across socioeconomic categories, may also influence weight control practices, which appeared to be more frequent among women and among persons with higher socioeconomic status (Wardle and Steptoe 2003). Limited access to medical care among women with less favourable socioeconomic status (Scuteri et al. 2008) might lead to the absence of prevention and management of MetS. In addition, some prospective surveys have found differences according to sex. Participation in cultural activities, including school tasks and homework, was found to be associated with lower risk of Mets in girls (and then later in women), but not in boys (Cuypers et al. 2012). Depression was also found to be associated with increased risk of MetS in women, but not in men (Pulkki-Raback et al. 2009). Socioeconomic status is usually considered a complex phenomenon combining occupational, educational and financial influences (Winkleby et al. 1992). Although these three dimensions are interrelated, they are usually considered to be conceptually distinct rather than redundant variables (Turrell et al. 2003). However, including them simultaneously as covariates in logistic regression analyses might lead to overadjustment.

However, previous hypotheses are not sufficient to explain differential associations between men and women. Men born outside of France tend to have higher MetS risk than those born in France. However, this finding needs to be confirmed in larger samples since the number of men born outside France in our survey was rather small ($n = 72$), most of them being born in Africa. Though data on CVD risk factors among migrants in Europe are relatively scarce, particularly in France, previous surveys reported higher risk of obesity, reduced HDL-c and type 2 diabetes among Turkish and Moroccan immigrants compared to host populations (Ujcic-Voortman et al. 2012). Indeed, Turkish and Moroccan migrants are among the largest ethnic minority groups in Europe. In addition, obesity and diabetes constitute frequent health problems in Turkey and Morocco (Tazi et al. 2003), possibly due to a genetic predisposition. In France, the prevalence of type 2 diabetes was reported to be twice as high in women of North African origin as in women of French origin, at a similar socioeconomic status and level of obesity; no such association was found in men (Fosse and Fagot-Campagna 2011).

## Strengths and limitations

Our survey was based on national recruitment, and analyses were carried out on measured anthropometric data collected by trained physicians, nurses and dieticians. For each participant, anthropometric measurements and biochemical assessments were performed on the same day. Since our results are based on a cross-sectional survey, underlying mechanisms cannot be inferred. The rather small sample size, particularly for men with low education, may have limited the power of the study. The participation

rate was considered acceptable for the food consumption survey (about 60 %), but was lower for the health examination survey (about 40 %), although participation in the health examination was greatly improved by home visits. Interest in nutrition, healthy behaviour and health status may have influenced participation in the survey. This participation bias was taken into account by a calibration procedure according to national census data. The existence of different MetS definitions raises the question of their capacity to identify individuals at high risk of CVD, since the NCEP/ATP III and AHA/NHLBI definitions have been found to be more predictive of CVD risk than the JIS definition (Athyros et al. 2010; Luksiene et al. 2011). In addition, comparisons between surveys and extrapolation of their findings are difficult due to the lack of a standardised MetS definition.

In conclusion, MetS prevalence appears to be lower in France than in most industrialised countries whatever the MetS definition used. MetS tends to be more frequent in women with a lower education level and in men born outside of France. Since ageing and the trend toward increasing obesity are expected to contribute to a rise in MetS prevalence, it is urgent to promote lifestyle changes, particularly among persons belonging to less favourable socioeconomic categories and migrants, so as to prevent MetS incidence in the overall French population.

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