Household Income Is Associated With the Risk of Metabolic Syndrome in a Sex-Specific Manner

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OBJECTIVE — To assess the relationship between household income and metabolic syndrome in men and women.

RESEARCH DESIGN AND METHODS — A total of 1,695 men and 1,664 women, aged 35–64 years, from three distinct geographical areas of France were investigated. Waist girth, plasma triglycerides, HDL cholesterol, glucose, and systolic blood pressure were used to define metabolic syndrome according to the National Cholesterol Education Program (NCEP)/Adult Treatment Panel III (ATPIII) guidelines. Household income, educational level, occupational category, working status, consumption of psychotropic drugs, accommodation status, household composition, physical activity at work and during leisure time, alcohol consumption, and smoking habits were recorded with a standardized questionnaire.

RESULTS — There were 390 (23.0%) men and 381 (16.9%) women who satisfied NCEP/ATPIII criteria for metabolic syndrome. Household income ($P < 0.0001$) and consumption of psychotropic drugs ($P = 0.0005$) were associated with metabolic syndrome in women but not in men. In contrast, educational level, occupational category, working status, and accommodation status were associated with metabolic syndrome in both men and women. After adjustment on lifestyle variables, household income (interaction $P < 0.004$) remained inversely associated with metabolic syndrome in women but not in men.

CONCLUSIONS — These data suggest that limited household income, which reflects a complex unfavorable social and economic environment, may increase the risk of metabolic syndrome in a sex-specific manner.

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The metabolic syndrome is characterized by the clustering of several metabolic disorders (1,2). The latter are influenced by nutritional habits and physical activity (3–6). Several working definitions have been proposed for metabolic syndrome (7), including increased body weight, insulin resistance, elevated plasma triglyceride levels, low HDL cholesterol, high blood pressure, and altered glucose homeostasis. These factors independently and in combination increase the risk of cardiovascular disease and diabetes (8–11).

In the U.S., the prevalence of metabolic syndrome has been estimated to be 22.8 and 22.6% in men and women, respectively (12). The distribution of the syndrome varies among different categories of the population. Increasing evidence (13–21) indicates that social indicators and psychological factors are strongly associated with the risk of insulin resistance, hypertriglyceridemia, hypertension, obesity, and metabolic syndrome. People from the lowest social categories are more likely to develop several metabolic disorders or metabolic syndrome. The mechanisms involved in these associations are not totally elucidated. Social factors, educational level, and economic indicators are strongly interrelated. These factors influence nutritional habits, physical activity, and healthy behaviors possibly affecting the clustering of metabolic disorders (22,23).

Very little is known about the influence of household income on the risk of metabolic syndrome. The reason is the limited number of studies that recorded information on this indicator. Earlier studies (24–26) have reported an inverse relationship between household income and obesity that is compatible with a higher risk of metabolic syndrome in people with limited economic resources. In the present study, we hypothesized that household income might influence the risk of metabolic syndrome. Therefore, we investigated the relationship between household income and metabolic syndrome in a large sample of men and women in which social indicators and lifestyle variables were recorded.

RESEARCH DESIGN AND METHODS

— Participants were recruited in the framework of the World Health Organization Monitoring Trends and Determinants in Cardiovascular Dis-

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Abbreviations: ATPIII, Adult Treatment Panel III; Monitoring Trends and Determinants in Cardiovascular Disease; NCEP III, National Cholesterol Education Program III.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

ease (MONICA) population survey conducted from 1995 to 1997 in three distinct geographical areas in France: the urban community of Lille in the north, the district of Bas-Rhin in the east, and the district of Haute-Garonne in the south of France. The sample included representative subjects aged 35–64 years, stratified by town size, randomly selected from the electoral rolls to obtain 200 participants for each sex and 10-year age-group (World Health Organization MONICA project protocol [27]). A total of 1,778 men and 1,730 women completed the recruitment procedure. The local ethical committee approved the protocol.

After signing an informed consent, participants were administered a standard questionnaire, and physical measurements were made by a specially trained nurse. The questionnaire covered questions on socioeconomic factors, physical activity at work and during leisure activities, alcohol consumption, smoking status, personal medical history, family history, attitudes and knowledge concerning several diseases, and current drug therapy.

The level of physical activity during leisure time was self-reported as no physical activity, light (light physical activity almost every week), and intense (at least 20 min more than once a week). Physical activity at work was divided into four groups: sedentary, regular walking and handling of <10-kg parcels (light), handling of 10- to 24-kg parcels (average), and handling of >25-kg loads (heavy). Current cigarette smokers were defined as subjects reporting at least one cigarette per day. Total alcohol intake was expressed as the sum of milliliters of alcohol per week from wine, beer, cider, and spirits. Household income was estimated by family income tax classified in four categories: no income tax, <760 euros, 760–2,300 euros, and >2,300 euros. These cut points approximately corresponded to the tertile of family income in France at the time of the study. The educational level was assessed by counting the number of years of schooling and classified in three categories: primary, secondary or technical, and university. Occupational categories were classified according the French National Institute of Statistics and Economic Studies in five categories: unskilled manual workers, company clerks, middle executives, and senior executives. Working status included retired and no professional activity, working full or part time, disability, and unemployed. Psychotropic drug consumption included tranquillizer, antidepressant, and hypnotic. The number of people living in the household was assessed. Accommodation status was either owner or living in a rented accommodation.

The anthropometric measurements included body weight (rounded to the nearest even decimal), waist girth (at a level midway between lower rib margin and iliac crest; to the nearest 0.5 cm), and height (to the nearest centimeter) and were taken on subjects in light clothing without shoes. BMI was calculated according to the Quetelet equation. Blood pressure was measured on the right arm, with the subject in a sitting position and after a minimum 5-min rest, using a standard mercury sphygmomanometer. Two consecutive measures of systolic and diastolic blood pressure were recorded to the nearest 2 mmHg. The second blood pressure record was taken at least 1 min after the first one. The mean value of the two blood pressure readings was taken into account.

Metabolic syndrome was defined, according to the National Cholesterol Education Program (NCEP)/Adult Treatment Panel III (ATPIII) recommendations (28), by the presence of at least three or more of the following abnormalities: waist girth >102 cm in men and >88 cm in women, triglycerides ≥150 mg/dl, HDL cholesterol <40 mg/dl in men and <50 mg/dl in women, blood pressure ≥130/85 mmHg or treatment with blood pressure–lowering medications, and fasting glucose ≥110 mg/dl or treatment for diabetes. Eighty-two subjects with triglycerides <150 mg/dl could not be classified because of fibrate treatment. These subjects were excluded from the analyses.

After the subjects had fasted for at least 10 h, a 20-ml blood sample was drawn on disodium EDTA, kept at room temperature, and centrifuged within 4 h. Lipid and lipoprotein levels were measured centrally at the Purpan Hospital Biochemical Laboratory (Toulouse, France). The quality of biological measurements was assessed within the framework of the MONICA project. Glucose was measured by the glucose oxidase method (DuPont Dimension). Plasma insulin was measured by radioimmunoassay (BiInsuline; Eria Pasteur). Serum triglyceride and HDL cholesterol levels were measured enzymatically (DuPont Dimension).

Statistical analyses

Statistical analyses were performed with the SAS System for Windows (SAS Institute, Cary, NC). The general linear model procedure and logistic regression analyses were used to compare continuous and categorical variables, respectively. Logistic regression analyses was used to assess the association between household income and metabolic syndrome using age and center as covariables. To compare the association in men and women, an interaction term for sex and the social variable of interest, separately, was fitted to the model together with age, center, physical activity, alcohol consumption, smoking habits, and household composition. The Wald statistic was used to test the statistical significance of the interaction term.

RESULTS — At total of 23% of men and 16.9% of women, aged 35–64 years, satisfied NCEP/ATPIII criteria for metabolic syndrome (Table 1). The prevalence increased across age categories and was lower in southern France (Toulouse) than in the east (Strasbourg) or the north (Lille). Physical activity during leisure time was inversely associated with metabolic syndrome in both sexes ($P < 0.0001$). Physical activity at work was positively correlated with metabolic syndrome in women ($P < 0.0002$) but not in men. Smoking and alcohol consumption were associated with metabolic syndrome in men ($P < 0.011$, $P < 0.0003$, respectively) and women ($P < 0.0001$, $P < 0.04$, respectively). BMI, waist circumference, insulin, glucose, triglycerides, and blood pressure were higher, and HDL cholesterol was lower in both men and women (all variables $P < 0.0001$) with metabolic syndrome than in control subjects (Table 1).

The household income was inversely associated with metabolic syndrome in women ($P < 0.0001$) but not in men (Table 2). Educational level was inversely associated with metabolic syndrome in both men and women (both $P < 0.0001$). Similarly, the mean duration of schooling was lower in men and women with metabolic syndrome than in control subjects ($P < 0.0001$). Both men ($P < 0.0005$) and women ($P < 0.0012$) living in rented accommodations were more likely to be affected by metabolic syndrome than

Table 1—*Characteristics of the subjects with metabolic syndrome and control subjects according to sex*

	Men			Women		
	Control subjects	Metabolic syndrome	*P*	Control subjects	Metabolic syndrome	*P*
n (%)	1,305 (77.0)	390 (23.0)		1,383 (83.1)	281 (16.9)	
Age (years)			<0.0001			<0.0001
35–44	37.2	21.5		37.8	13.9	
45–54	32.4	36.2		33.6	35.9	
55–65	30.4	42.3		28.6	50.2	
Center (%)			0.0003			0.0014
Lille	31.8	36.9		32.8	40.9	
Strasbourg	30.4	36.4		31.8	34.5	
Toulouse	37.8	26.7		35.4	24.6	
Physical activity (%)			<0.0001			<0.0001
No	16.4	22.9		24.6	36.4	
Light	46.1	52.9		51.5	54.3	
High	37.5	24.2		23.9	9.3	
Physical activity at work (%)			0.34			0.0002
Sedentary	41.8	37.5		50.4	35.5	
Light	29.4	29.4		34.2	42.6	
Average	17.5	19.5		10.4	13.9	
Heavy	11.3	13.8		4.8	8.0	
Smoking (%)			0.011			<0.0001
Never	32.7	25.6		62.6	76.5	
Former	40.3	48.0		18.4	13.5	
Current	27.0	26.4		19.0	10.0	
Alcohol (g/week)	262 ± 255	330 ± 500	0.0003	79.7 ± 110	97 ± 163	0.04
BMI (kg/m^2)	25.6 ± 3.1	30.3 ± 4.0	<0.0001	24.6 ± 4.2	31.6 ± 5.4	<0.0001
Waist girth (cm)	92.5 ± 9.1	106.2 ± 9.8	<0.0001	80.5 ± 11.0	101.1 ± 11.5	<0.0001
Glycemia (mg/dl)	98.5 ± 13.3	119.4 ± 34.9	<0.0001	92.3 ± 10.2	117.9 ± 36.7	<0.0001
Insulinemia (μU/l)	10.2 ± 10.2	16.9 ± 10.9	<0.0001	9.6 ± 5.0	15.5 ± 8.0	<0.0001
Systolic blood pressure (mmHg)	132.8 ± 17.2	146.3 ± 18.9	<0.0001	125.7 ± 18.2	144.0 ± 19.1	<0.0001
Triglycerides (mg/dl)	105.4 ± 64.5	222.2 ± 146.8	<0.0001	80.5 ± 33.0	171.2 ± 113.5	<0.0001
HDL cholesterol (mg/dl)	53.9 ± 13.8	41.2 ± 10.6	<0.0001	66.8 ± 16.5	47.4 ± 13.1	<0.0001

Data are means ± SD, unless otherwise indicated. Logistic regression analysis was used for statistical analyses with age, center, and each variable separately (except for age and center). General linear model was used to compare continuous variables between subjects with the metabolic syndrome and control subjects, adjusting for age and center.

owners. Occupational category was associated with metabolic syndrome in both sexes ($P = 0.0003$ in men and $P < 0.0001$ in women). Unskilled manual workers were more likely to present a metabolic syndrome than control subjects. Consumption of psychotropic drugs was associated with metabolic syndrome in women ($P < 0.0005$) but not in men. Number of individuals in the household was inversely associated with metabolic syndrome in men ($P < 0.03$) but not in women. Finally, working status was associated to metabolic syndrome in men ($P = 0.0003$) and women ($P < 0.0001$). There were less active workers among the metabolic syndrome group than in the control group (Table 2).

To compare the impact of economic and social factors on metabolic syndrome in men and women, logistic regression analyses were performed with an interaction term for sex and the variable of interest, adjusting for age, center, physical activity, alcohol consumption, smoking habits, and household composition (Table 3). Household income remained inversely associated with metabolic syndrome in women (trend $P < 0.0001$) but not in men (trend $P < 0.12$, interaction between sex and household income $P = 0.0004$). Educational level was inversely associated with metabolic syndrome in men (trend $P < 0.0003$) and women (trend $P < 0.0001$, interaction $P < 0.011$). Accommodation status was associated with metabolic syndrome in men (trend $P < 0.0023$) and women (trend $P < 0.0045$, interaction was nonsignificant $P = 0.89$). Occupational category was associated with metabolic syndrome in men (trend $P < 0.0071$) and women (trend $P < 0.0004$, interaction $P = 0.056$). Psychotropic drug use was associated with metabolic syndrome in women (trend $P < 0.0009$) but not in men (trend $P < 0.22$, interaction $P = 0.18$).

To gain further insight to the relationship between household income and metabolic syndrome, logistic regression analyses were performed with household income and each metabolic disorder separately, adjusting for age, center, physical activity, alcohol consumption, smoking habits, and household composition (Fig. 1). In women, household income was inversely associated with increased waist girth ($P < 0.001$), HDL levels ($P < 0.04$), blood pressure ($P < 0.01$), and glycemia

Table 2—*Household income, education, social status and psychotropic drug use distribution in subjects with metabolic syndrome and control subjects according to sex*

	Men			Women		
	Control subjects	Metabolic syndrome	*P*	Control subjects	Metabolic syndrome	*P*
Household income (%)			0.15			<0.0001
No income tax	19.0	22.1		22.8	41.5	
<760 euros	13.1	17.2		15.6	18.2	
760–2,300 euros	35.5	32.6		30.7	23.7	
>2,300 euros	32.4	28.1		30.9	16.7	
Educational level (%)			<0.0001			<0.0001
Primary	15.6	26.4		24.1	49.5	
Intermediate, technical	45.4	48.5		41.8	37.4	
University	38.9	25.1		34.1	13.2	
Years of schooling	12.5 ± 3.9	11.3 ± 3.6	<0.0001	11.9 ± 3.5	9.8 ± 3.1	<0.0001
Accommodation status (%)			0.0005			0.0012
Owners	78.6	70.4		76.8	68.6	
Tenants	21.4	29.6		23.2	31.4	
Occupational category (%)			0.0003			<0.0001
Unskilled manual	29.6	35.4		11.7	20.5	
Employee	10.8	14.4		45.1	50.9	
Middle executive	40.5	40.5		33.4	24.2	
Senior executive	19.1	9.7		9.9	4.4	
Psychotropic drug use (%)	5.9	9.2	0.15	12.0	21.7	0.0005
Number in the household	3.2 ± 2.9	2.9 ± 1.3	0.024	2.9 ± 1.7	2.8 ± 1.4	0.12
Working status (%)			0.0003			<0.0001
Retirement and never worked	20.5	28.0		30.4	49.1	
Full time/part time	73.6	63.1		62.0	39.9	
Disability pension	2.0	3.6		2.0	3.2	
Unemployment	3.9	5.4		5.6	7.8	

Data are means ± SD or percentage. Logistic regression analysis was used for statistical analyses with age, center, and each variable separately. General linear model was used to compare continuous variables between subjects with the metabolic syndrome and control subjects, adjusting for age and center.

($P < 0.02$). In men, there was no evidence for significant associations between household income and any of the metabolic disorders separately.

CONCLUSIONS — The principal finding of the present study is that household income is inversely associated with the risk of metabolic syndrome in women. After adjustment on lifestyle factors, the relationship remained statistically significant. These data suggest that limited household income, which reflects a complex unfavorable social and economic environment, may increase the risk of metabolic syndrome in a sex-specific manner.

The observation of an inverse association between metabolic syndrome and household income in women, but not in men, suggests that economic constraints may increase the risk of metabolic syndrome in women. These data are consistent with previous reports (24–26) that had shown stronger association between household income and waist girth in women than in men. Our study further extends this observation to metabolic syndrome. One possible explanation to this finding is that limited resources bring people to choose low-cost, energy-dense food, which favors the development of insulin resistance, hypertriglyceridemia, and body weight gain (23). In support of this hypothesis, it has been shown that foods composed of fat, refined grain, and added sugar are the lowest-cost options for consumers in France (29). Limited resources may also affect the ability to practice leisure activity, resulting in a higher risk of metabolic syndrome. However, these hypotheses do not clearly explain the sex difference, since both men and women from the lower household income category should be similarly affected by inappropriate food choice and lack of leisure activity. Therefore, another explanation could be that women in the lowest household income category are likely unemployed and bothered by limited resources, resulting in reduced physical activity and/or increased stress. This in turn may favor body weight gain and insulin resistance (25). In agreement with this hypothesis, women in the bottom income group were more often unemployed and consume more psychotropic drugs than women in the upper household income category.

In contrast with women, household income was not associated with metabolic syndrome or any of its components separately in men. Interestingly, the prevalence of metabolic syndrome tended to be higher in men from the upper than the lower income category, whereas the opposite was observed in women. Therefore, one explanation could be that men from the top income category, because of cultural and personal beliefs, care less for healthy food choices and physical activity than women from the same income range. Furthermore, men in the bottom income group have a more physical occupation that might protect them from developing

Table 3—*Age- and center-adjusted odds ratios of metabolic syndrome for household income, educational level, and accommodation status by sex*

	Men		Women		*P* interaction with sex
	Odds ratio (95% CI)	*P* trend	Odds ratio (95% CI)	*P* trend	
Household income (%)					
No income tax	Ref.	0.12	Ref.	<0.0001	0.0004
<760 euros	1.16 (0.78–1.72)		0.66 (0.44–0.99)		
760–2,300 euros	0.91 (0.64–1.13)		0.52 (0.36–0.76)		
>2,300 euros	0.82 (0.58–1.16)		0.38 (0.25–0.57)		
Educational level (%)					
Primary	Ref.	0.0003	Ref.	<0.0001	0.011
Intermediate, technical	0.74 (0.54–1.01)		0.61 (0.44–0.84)		
University	0.52 (0.37–0.73)		0.33 (0.22–0.51)		
Accomodation status (%)					
Owners	Ref.	0.0023		0.0045	0.89
Tenants	1.54 (1.16–2.03)		1.54 (1.12–2.10)		
Occupational category (%)					
Unskilled manual	Ref.	0.0071	Ref.	0.0004	0.056
Employee	1.20 (0.82–1.75)		0.71 (0.48–1.05)		
Middle executive	0.89 (0.67–1.74)		0.52 (0.34–0.81)		
Senior executive	0.50 (0.33–0.75)		0.36 (0.18–0.73)		
Psychotropic drug use (%)					
No	Ref.	0.22	Ref.	0.0009	0.18
Yes	1.37 (0.89–2.11)		1.94 (1.36–2.77)		

Logistic regression analysis was used for statistical analyses with age, center, physical activity, alcohol consumption, smoking habit, and household composition and each variable separately.

metabolic syndrome. Altogether, household income is a social and economic indicator associated with health behaviors that result in a higher risk of metabolic syndrome in women.

Educational level is an important cofactor of the relationship between household income and metabolic syndrome. In the present study, the level of education was inversely related to metabolic syndrome in both men and women; however, it was more strongly inversely related in women than in men (interaction $P < 0.011$). This is consistent with previous studies (16–20) that reported more pronounced inverse associations between educational level and features of metabolic syndrome in women than in men. The reasons for this association might be related to the influence of education in predicting food choices (22,30–33) and healthy behaviors (30,34), both of which are related to metabolic syndrome. Since education facilitates the understanding and acquisition of healthy lifestyles and since women are generally more health conscious than men, the combination of both factors might explain the greater protection against metabolic syndrome in educated women.

Housing status is an indicator of social position that is linked to household income. In this study, living in a rented

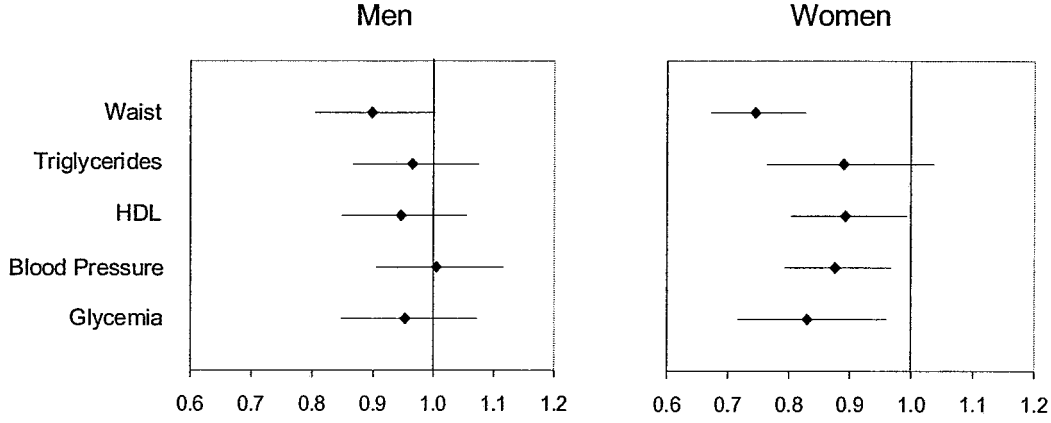

Figure 1—*Adjusted odds ratio of metabolic disorders for a 1-unit increase in household income in men and women. Metabolic disorders were defined according to the NCEP III definition. Logistic regression analyses was used to assess the odds ratio of metabolic disorders using age, center, physical activity, alcohol consumption, smoking habits, and household composition as covariables.*

accommodation is associated with metabolic syndrome in men and women. The mechanism through which housing status influences metabolic syndrome is speculative. Living in a rented accommodation might reflect a lower social position, which might generate chronic stress resulting in insulin resistance and hypertriglyceridemia (35–37). Consistent with this hypothesis, previous works (17,18) have reported that the risk of insulin resistance and obesity is related to the neighborhood characteristics and accommodation status. Therefore, accommodation status might aggregate several indicators of social position that influence the risk of metabolic syndrome.

This study has several strengths and limitations. It was conducted in three representative samples of men and women from different regions of France, therefore providing a large variety of social and economical situations. However, indicators of social position, wealth, and educational level are highly interrelated, which makes it difficult to determine the precise individual contribution of each factor. Furthermore, due to the strong interrelations among social indicators, there is always a possibility that unmeasured factors may confound the observations. Another study limitation is the cross-sectional nature of the study, which does not allow inferring a causal relationship. Moreover, reverse causation, the extent of which metabolic syndrome and poor health lead to low income, could be of some concern. In addition, we used family income tax as a proxy of household income despite well-identified conceptual difficulties.

In conclusion, household income is a social and economic indicator that aggregates several indicators of social position. In the present study, household income is inversely associated with metabolic syndrome in women. These data suggest that low social position, reflected by limited familial income, may increase the risk of metabolic syndrome in a sex-specific manner.

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References

1. Reaven GM: Banting Lecture 1988: Role of insulin resistance in human disease. *Diabetes* 37:1595–1607, 1988
2. Timar O, Sestier F, Levy E: Metabolic syndrome X: a review. *Can J Cardiol* 16:779–789, 2000
3. Rosell MS, Hellenius ML, de Faire UH, Johansson GK: Associations between diet and the metabolic syndrome vary with the validity of dietary intake data. *Am J Clin Nutr* 78:84–90, 2003
4. Williams DE, Prevost AT, Whichelow MJ, Cox BD, Day NE, Wareham NJ: A cross-sectional study of dietary patterns with glucose intolerance and other features of the metabolic syndrome. *Br J Nutr* 83:257–266, 2000
5. Mayer-Davis EJ, D'Agostino R Jr, Karter AJ, Haffner SM, Rewers MJ, Saad M, Bergman RN: Intensity and amount of physical activity in relation to insulin sensitivity: the Insulin Resistance Atherosclerosis Study. *JAMA* 279:669–674, 1998
6. Laaksonen DE, Lakka HM, Salonen JT, Niskanen LK, Rauramaa R, Lakka TA: Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. *Diabetes Care* 25:1612–1618, 2002
7. Grundy SM, Brewer HB Jr, Cleeman JI, Smith SC Jr, Lenfant C, National Heart, Lung, and Blood Institute, American Heart Association: Definition of metabolic syndrome: report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition (Review). *Arterioscler Thromb Vasc Biol* 24:E13–E18, 2004
8. Isomaa B, Almgren P, Tuomi T, Forsen B, Lahti K, Nissen M, Taskinen MR, Groop L: Cardiovascular morbidity and mortality associated with the metabolic syndrome. *Diabetes Care* 24:683–689, 2001
9. Lakka HM, Laaksonen DE, Lakka TA, Niskanen LK, Kumpusalo E, Tuomilehto J, Salonen JT: The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. *JAMA* 288:2709–2716, 2002
10. Hanson RL, Imperatore G, Bennett PH, Knowler WC: Components of the "metabolic syndrome" and incidence of type 2 diabetes. *Diabetes* 51:3120–3127, 2002
11. Laaksonen DE, Lakka HM, Niskanen LK, Kaplan GA, Salonen JT, Lakka TA: Metabolic syndrome and development of diabetes mellitus: application and validation of recently suggested definitions of the metabolic syndrome in a prospective cohort study. *Am J Epidemiol* 156:1070–1077, 2002
12. Park YW, Zhu S, Palaniappan L, Heshka S, Carnethon MR, Heymsfield SB: The metabolic syndrome: prevalence and associated risk factor findings in the US population from the Third National Health and Nutrition Examination Survey, 1988–1994. *Arch Intern Med* 163: 427–436, 2003
13. Kaplan GA, Lynch JW: Socioeconomic considerations in the primordial prevention of cardiovascular disease (Review). *Prev Med* 29:S30–S35, 1999
14. Everson SA, Maty SC, Lynch JW, Kaplan GA: Epidemiologic evidence for the relation between socioeconomic status and depression, obesity, and diabetes. *J Psychosom Res* 53:891–895, 2002
15. Rosmond R, Bjorntorp P: Psychosocial and socio-economic factors in women and their relationship to obesity and regional body fat distribution. *Int J Obes Relat Metab Disord* 23:138–145, 1999
16. Lidfeldt J, Nyberg P, Nerbrand C, Samsioe G, Schersten B, Agardh CD: Socio-demographic and psychosocial factors are associated with features of the metabolic syndrome: the Women's Health in the Lund Area (WHILA) Study. *Diabetes Obes Metab* 5:106–112, 2003
17. Diez Roux AV, Jacobs DR, Kiefe CI: Neighborhood characteristics and components of the insulin resistance syndrome in young adults: the Coronary Artery Risk Development in Young Adults (CARDIA) Study. *Diabetes Care* 25:1976–1982, 2002
18. Wardle J, Waller J, Jarvis MJ: Sex differences in the association of socioeconomic status with obesity. *Am J Public Health* 92: 1299–1304, 2002
19. Brunner EJ, Marmot MG, Nanchahal K, Shipley MJ, Stansfeld SA, Juneja M, Alberti KG: Social inequality in coronary risk: central obesity and the metabolic syndrome: evidence from the Whitehall II Study. *Diabetologia* 40:1341–1349, 1997
20. Wamala SP, Lynch J, Horsten M, Mittleman MA, Schenck-Gustafsson K, Orth-Gomer K: Education and the metabolic syndrome in women. *Diabetes Care* 22: 1999–2003, 1999
21. Horsten M, Mittleman MA, Wamala SP, Schenck-Gustafsson K, Orth-Gomer K: Social relations and the metabolic syndrome in middle-aged Swedish women. *J Cardiovasc Risk* 6:391–397, 1999
22. Booth SL, Sallis JF, Ritenbaugh C, Hill JO, Birch LL, Frank LD, Glanz K, Himmelgreen DA, Mudd M, Popkin BM, Rickard KA, St Jeor S, Hays NP: Environmental and societal factors affect food choice and physical activity: rationale, influences,

and leverage points. *Nutr Rev* 59:S21–S39, 2001
23. Drewnowski A, Specter SE: Poverty and obesity: the role of energy density and energy costs. *Am J Clin Nutr* 79:6–16, 2004
24. Ecob R, Smith GD: Income and health: what is the nature of the relationship? *Soc Sci Med* 48:693–705, 1999
25. Sarlio-Lahteenkorva S, Lahelma E: The association of body mass index with social and economic disadvantage in women and men. *Int J Epidemiol* 28:445–449, 1999
26. Jeffery RW, Forster JL, Folsom AR, Luepker RV, Jacobs DR Jr, Blackburn H: The relationship between social status and body mass index in the Minnesota Heart Health Program. *Int J Obes* 13:59–67, 1989
27. WHO-MONICA Project Principal Investigators: The WHO-MONICA Project: a major international collaboration. *J Clin Epidemiol* 41:105–114, 1988
28. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol In Adults (Adult Treatment Panel III). *JAMA* 285:2486–2497, 2001
29. Darmon N, Briend A, Drewnowski A: Energy-dense diets are associated with lower diet costs: a community study of French adults. *Public Health Nutr* 7:21–27, 2004
30. Wardle J, Parmenter K, Waller J: Nutrition knowledge and food intake. *Appetite* 34:269–275, 2000
31. Hjartaker A, Lund E: Relationship between dietary habits, age, lifestyle, and socio-economic status among adult Norwegian women: the Norwegian Women and Cancer Study. *Eur J Clin Nutr* 52:565–572, 1998
32. Irala-Estevez JD, Groth M, Johansson L, Oltersdorf U, Prattala R, Martinez-Gonzalez MA: A systematic review of socio-economic differences in food habits in Europe: consumption of fruit and vegetables. *Eur J Clin Nutr* 54:706–714, 2000
33. Dallongeville J, Marecaux N, Cottel D, Bingham A, Amouyel P: Association between nutrition knowledge and nutritional intake in middle-aged men from Northern France. *Public Health Nutr* 4:27–33, 2001
34. Luepker RV, Rosamond WD, Murphy R, Sprafka JM, Folsom AR, McGovern PG, Blackburn H: Socioeconomic status and coronary heart disease risk factor trends: the Minnesota Heart Survey. *Circulation* 88:2172–2179, 1993
35. Brunner E: Stress and the biology of inequality. *BMJ* 314:1472–1476, 1997
36. Muldoon MF, Herbert TB, Patterson SM, Kameneva M, Raible R, Manuck SB: Effects of acute psychological stress on serum lipid levels, hemoconcentration, and blood viscosity. *Arch Intern Med* 155:615–620, 1995
37. McCann BS, Magee MS, Broyles FC, Vaughan M, Albers JJ, Knopp RH: Acute psychological stress and epinephrine infusion in normolipidemic and hyperlipidemic men: effects on plasma lipid and apoprotein concentrations. *Psychosom Med* 57:165–176, 1995