Prevalence And Lifestyle Determinants Of The Metabolic Syndrome

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Abstract

Participants with the metabolic syndrome are at risk of developing type 2 diabetes and coronary heart disease. The aim of this study was to determine the role of lifestyle risk factors in the development of the metabolic syndrome with particular reference to physical activity, smoking and alcohol consumption. We performed a cross sectional study of the prevalence of CVD risk factors and glucose intolerance, including type 2 diabetes involving a group of 1473 men and women were sampled from 17 general practice lists in the South of Ireland. A total of 1018 attended for screening, giving a response rate of 69%. Participants completed a detailed health and lifestyle questionnaire and provided fasting blood samples for analysis of glucose, insulin and lipids. The metabolic syndrome was defined according to the current WHO criteria. The prevalence of the metabolic syndrome was 21.0% (95% C.I. 18.7% to 24.1%). In multivariate analyses with the metabolic syndrome as the dependent variable we observed a significant, independent inverse association with physical activity level (OR=0.60; 95%CI, 0.39−0.90 for medium and OR=0.51; 95%CI, 0.28−0.93) for high level of activity relative to the low level of activity group). Ex−drinkers had a higher prevalence of the syndrome in multivariate analysis relative to occasional drinkers, (OR=2.38; 95%CI, 1.08−5.26). Prevalence of the metabolic syndrome was not significantly associated with current alcohol consumption or with smoking status. These data highlight the importance of physical inactivity in the aetiology of the metabolic syndrome.

Introduction

The metabolic syndrome has been proposed to include a set of metabolic and anthropometric characteristic of which glucose intolerance, hyperinsulinemia, hypertriglyceridemia, hypertension, reduced concentration of HDL−cholesterol, and central obesity are the predominant components,[1]. A number of other abnormalities including microalbuminuria, hyperfibrinogenaemia, hyperuricaemia, increased levels of plasminogen activator inhibitor, and low concentrations of tissue plasminogen activator have also been associated with the syndrome,[2]. As in any syndrome not all the features are present in the same individual. The syndrome has been given different names such as the insulin resistance syndrome, or syndrome X1,[3] and the deadly quartet,[4]. The metabolic syndrome is an important marker of increased risk for both cardiovascular disease and type 2 diabetes,[5,6].

The lack of an accepted definition has impeded epidemiological research on this disorder[7]. Two definitions of the syndrome have been proposed, one by the World Health Organization (WHO) and a second definition in the US Third Report of the National Cholesterol Education Program, Adult Treatment Panel, ATP III 2001,[8,9]. There is evidence that the WHO criteria for the metabolic syndrome are more effective in predicting CVD events[10]. We have reported the prevalence of the metabolic syndrome defined according to both criteria in a sample of men and women aged 50 to 69 years, participants in the Cork & Kerry Diabetes & Heart disease Study,[11,12]. In our earlier communication[12] we have not addressed determinants of the metabolic syndrome. The western lifestyle with its high prevalence of obesity and physical inactivity is thought to be central to the development of this syndrome[13]. The aims of this study were to investigate associations between physical activity, alcohol consumption and cigarette smoking and the prevalence of the metabolic syndrome according to the WHO criteria in a general population sample of middle−aged men and women.

Methods

Design, subjects and methods of data collection.

The Cork and Kerry Diabetes and Heart Disease Study, is a cross−sectional study of the prevalence of glucose intolerance and associated cardiovascular disease risk factors in an Irish general population sample. Details of the practices, methods of sampling and methods of data collection, including the self−completed questionnaire data, physical measurements (height, weight, waist and hip circumference and fasting blood samples have been described,[11].

Stratified random sampling by age and sex was employed to recruit equal numbers of men and women in four age strata between the ages of 50 and 69 years. Subjects with cardiovascular disease, known diabetes mellitus or other disease, or those receiving medication were not excluded. From a total of 1473 men and women who were invited to participate, 1018 attended for the assessment (491 men and 527 women), a response rate of 69.1%. Allowing for those who could not attend by reason of being: hospitalised (N=5); out of the country (N=5); no longer alive (N=2); outside the target age group (N=2); too confused (N=1) and untraceable (N=2), the effective response was 69.9%.

Questionnaires and Physical Measurements − Physical activity

Physical activity was assessed using the British Regional Heart Study questionnaire,[14]. The questionnaire addresses the type and duration of exercise while travelling to work, the participants assessment of occupational physical activity, a grading (1−5) of week−end physical activity, the frequency of participation in active physical exercise such as running, digging, and tennis, and the number of years the subject had been involved in such activity. Participants were grouped into three physical activity categories: inactive & occasionally active (Low, N=407), light to moderate activity (Medium, N=387) and moderate to vigorous activity (High. N=144). Data on physical activity were not available for 80 participants.

Smoking status

Participants were classified according to their current smoking status into one of three categories: never smoker (n=463), ex−smoker (n=341) and current smoker (n=190). Data on smoking was not available for 24 participants. Never smokers were defined as those who answer no to the questions: Do you regularly smoke cigarettes at present? and if no, have you ever regularly done so?. Those that have only smoked pipe or cigars (n=2) and former cigarette smokers who smoke a pipe or cigars (n=11) were regarded as current smokers.

Socio−economic Status

Participants were classified by socio−economic categories, based on the standard occupational classification system of the Irish Central Statistics Office combined with educational attainment. When a participant defined herself as a housewife, the occupation of their partner was used for classification. We defined five socio−economic categories as follows: Category I (higher and lower professionals, employers/managers and own account workers with third level of education, N=161); Category II (employers, managers or own account workers without third level education, (N=64); Category III (farmers, N=138); Category IV (non−manual workers, skilled and semi−skilled manual workers (N=371); and Category V (agricultural workers and non−skilled manual workers N=255). Information for socio−economic status coding was not available for 29 participants.

Alcohol Intake

Alcohol intake was estimated primarily from the food frequency questionnaire data, cross−checked with the data from the lifestyle questionnaire. We used a food frequency questionnaire (FFQ) adapted from the UK −EPIC study instrument,[15], and subsequently modified by the Irish National Nutritional Surveillance Unit to reflect the Irish diet, [16−18]. Participants were classified into seven categories according to their alcohol intake: never (n=281), occasional (less than 0.5 units/day; n=341) light (0.5−0.99 units per day; n=118), moderate (1.0−2.99 units per day; n=70), heavy (more than 3 units per day; n=49), ex−drinkers (n= 43) and unclassified (n=31). Data was not available for 85 participants.

Blood Pressure Measurements

Blood Pressure was measured with the subject seated, with left arm at heart level, and cuff adjusted for arm circumference using a validated digital portable blood pressure monitor, (Omron HEM−705CP),[19]. Analyses were based on the mean of the second and third of three BP measurements. Data on the use of anti−hypertensive drugs was obtained from the self−completed questionnaire.

Anthropometric Measurements,

Urine Samples and Fasting Blood Samples

Body mass index (BMI) calculated as weight/height 2 (kg/m2) was used as an index of relative weight. Waist and hip measurements were taken using standard methods,[11], and waist hip ratio was used as a measure of central obesity. The data on height, weight, waist and hip circumference were based on the mean of two measurements.

Early urine samples (first void) were collected for measurement of albumin−creatinine ratio, expressed as mg/mmol. Urine samples were stored at 4o C and analysed within 24 hours using standard methods,[11].

In analysis of the glucose, insulin, HDL−cholesterol and triglyceride data, we excluded participants who did not fast for at least 8 hours (N= 51), those whose fasting status was unknown (N=50), and one participant with type 1 diabetes). The number of participants with valid data for glucose and insulin, triglycerides and HDL−cholesterol was 915, 900, 913 and 900 participants respectively.

Definition of the metabolic syndrome
According to the current WHO criteria, (MS WHO), the metabolic syndrome is defined on the basis of the following criteria: participants with glucose intolerance (impared fasting glucose and type 2 diabetes) and or insulin resistance (defined as the upper quartile of Glucose Homeostasis Model Scores (HOMA scores) with at least 2 of the following additional abnormalities: hypertension: defined as SBP> 140 mmHg and /or DBP > 90mmHg; dyslipidemia: defined as triglyceride > 1.7 mmol/L and/or low HDL < 0.9 mmol/L men, < 1.0 mmol/L women; obesity: defined as BMI > 30 Kg/m2 and/or WHR > 0.9 men, > 0.85 women; microalbuminuria: defined as albumin excretion rate of 20 micrograms/min or as microcreatine ratio > 30 mg/g.

Glucose intolerance was defined as those participants with type 2 diabetes or impaired fasting glucose, according to the current ADA and WHO criteria,[8, 20]. Insulin resistance was estimated on the basis of fasting glucose and insulin, using the glucose homeostasis model, (HOMA scores),[21]. Pre−existing cardiovascular disease was determined based on the following: a self reported history of myocardial infarction or angina) and/or a history of a Coronary Artery Bypass Graft or Coronary Artery Angioplasty) or a positive Rose Questionnaire or a history of stroke, peripheral vascular disease or abdominal aortic aneurysm or evidence of a definite previous myocardial infarction (MI) on an analysis of the electrocardiographs (ECG) by a single experienced cardiologist i.e. pathological Q wave > 1mm wide and > 3mm deep,[11].

Statistical analysis
Associations between the prevalence of the metabolic syndrome and physical activity, smoking status and alcohol intake were examined using logistic regression analysis with adjustment for age, sex, socio−economic status, pre−existing CVD and other potential confounding factors.

Results

Table 1 shows the prevalence of the metabolic syndrome and its components in this population. Three quarters of the sample met current criteria for central and/or overall obesity and almost half were hypertensive. The prevalence of the syndrome was 21.0% (95% C.I. 18.3% −23.7%) in the entire group. It was higher in men (24.61%) than in women (17.8%) and it increased with age, (Fig 1).

Table 1. Prevalence of the components of the metabolic syndrome in this population

	N (total)	Percentage	95%CI
Metabolic syndrome	890	21.0	18.4−23.8
Hypertension*	1018	47.2	44.0−50.3
Microalbuminuria	1017	8.0	6.4−9.8
Dyslipidaemia	899	29.0	26.1−32.1
Obesity	1014	75.9	73.2−78.5

Table 2 shows a logistic regression analysis with the metabolic syndrome as the dependent variable and physical activity as the independent variables before and after exclusion of participants with previously diagnosed diabetes. Physical activity was inversely and significantly associated with prevalence of the metabolic syndrome. This association was independent of age, sex, other environmental factors and pre−existing CVD. A dose−response gradient was also observed. The odds ratios for the metabolic syndrome associated with medium and high compared to low activity levels were 0.60 (95%CI, 0.39−92, P=0.02) and 0.53 (95%CI, 0.28−0.99, P=0.05) respectively (P for trend = 0.03), in multivariate analysis, excluding those with previously diagnosed diabetes.

Table 2. Logistic regression analysis with metabolic syndrome (WHO) as the dependent variable and physical activity as the independent variable, before and after exclusion of already diagnosed type 2 diabetics, N=823*

	All Participants			Previously Diagnosed Diabetics Excluded		
Exercise category	OR	(95% CI)	P value	OR	(95% CI)	P value
Adjusted+			Trend=0.03			Trend=0.06
Low	1.00			1.00		
Medium	0.69	0.48−0.99	0.05	0.71	0.48−1.04	0.08
High	0.54	0.31−0.94	0.02	0.58	0.33−1.02	0.06
Adjusted++			Trend=0.01			Trend=0.03
Low	1.00			1.00		
Medium	0.60	0.39−0.90	0.01	0.60	0.39−0.92	0.02
High	0.51	0.28−0.93	0.03	0.53	0.28−0.99	0.05

*N will vary in different analysis, as some variables have missing values.
+ Adjusted for age and sex.
++ Adjusted for age, sex, smoking, alcohol intake, socio−economic status and pre−existing CVD.

The prevalence of the metabolic syndrome was increased more than two−fold in ex−drinkers compared to occasional drinkers in univariate and multivariate analysis, Table 3. The odds ratio for the ex−drinker category compared to occasional drinkers was 2.56 (95%CI, 1.15−5.68, P=0.02), in multivariate analysis following exclusion of participants with previously diagnosed diabetes. We found no associations between the metabolic syndrome and other alcohol consumption categories.

Table 3. Logistic regression analysis with metabolic syndrome (WHO) as the dependent variable and alcohol intake as the independent variable, before and after exclusion of already diagnosed type 2 diabetics, N=793*

	All Participants			Previously Diagnosed Diabetics Excluded		
Alcohol category	OR	(95% CI)	P value	OR	(95% CI)	P value
Adjusted+			Trend=0.33			Trend=0.17
Occasional	1.00			1.00		
Never	1.07	0.69−1.65		0.98	0.62−1.55	0.18
Light	0.97	0.54−1.75	0.93	0.88	0.47−1.65	0.93
Moderate	1.34	0.68−2.62	0.39	1.34	0.67−2.68	0.70
Heavy	1.23	0.57−2.66	0.60	1.32	0.61−2.88	0.40
Ex−drinker	2.29	1.10−4.73	0.02	2.45	1.18−5.09	0.02
Adjusted++			Trend=0.23			Trend=0.15
Occasional	1.00			1.00		
Never	1.14	0.71−1.83	0.59	1.03	0.63−1.70	0.90
Light	0.89	0.46−1.71	0.73	0.84	0.42−1.68	0.62
Moderate	1.62	0.77−3.42	0.20	1.59	0.74−3.42	0.23
Heavy	1.51	0.64−3.56	0.34	1.60	0.68−3.80	0.23
Ex−drinker	2.38	1.08−5.26	0.04	2.56	1.15−5.68	0.02

*N will vary in different analysis, as some variables have missing values.
+ Adjusted for age and sex.
++ Adjusted for age, sex, smoking, socio−economic status, physical activity and pre−existing CVD.

Ex−smokers had a marginally significantly higher risk of the metabolic syndrome compared to never smokers in age and sex adjusted analysis, (OR=1.37, 95%CI, 0.95−1.99, P=0.09). No significant association with current smoking was observed.

Discussion
Approximately one fifth of Irish men and women in the 50 to 69 years age group meet current WHO criteria for the metabolic syndrome. These findings reflect the extremely high prevalence of obesity in this population with approximately three quarters of the sample meeting current criteria for central and or general obesity. There was a clear inverse association between the prevalence of the metabolic syndrome and levels of physical activity. No

consistent associations with alcohol consumption or smoking were observed.

The inverse association between metabolic syndrome prevalence and physical activity must be interpreted cautiously given the cross-sectional design of this study. However the association is plausible, given the associations between physical activity and major components of the metabolic syndrome, including hypertension, obesity, glucose intolerance, and insulin resistance[2]. The association was independent of potential confounders, including previously diagnosed diabetes and cardiovascular disease. There was a clear dose response gradient and the findings are consistent with previous studies[2,22,23]. Given the degree of random measurement error in the measurement of physical activity it is likely that the magnitude of the association has been underestimated.

We found that ex-drinkers had a higher prevalence of the metabolic syndrome as compared with our reference category of occasional drinkers. This association was not explained by higher levels of general or central obesity. BMI and waist-hip ratio did not vary significantly by alcohol consumption category. The association with ex- drinker status was observed in analyses adjusted for pre-existing cardiovascular disease, excluding participants with previously diagnosed diabetes. This association is particularly difficult to interpret in a cross-sectional study. There is considerable evidence from prospective studies that ex-drinkers are at increased risk of CHD incidence, CVD mortality and all cause mortality relative to occasional drinkers in analyses adjusted for lifestyle factors and pre-existing disease[6]. Thus, although we have adjusted for previous CVD and diabetes, ex-drinkers may have stopped drinking because of other less well defined health problems. These results confirm the need to separate ex-drinkers from never drinkers in studies of alcohol-disease relationships.

We found no significant association between smoking status and prevalence of the metabolic syndrome. This was unexpected given the evidence of a possible link between smoking and insulin resistance and risk of type 2 diabetes[24]. This negative finding may simply reflect the limited power of the study to examine this issue.
In summary, three quarters of this sample of middle aged men and women are obese, almost half are physically inactive and one in five meet current international criteria for the metabolic syndrome. It is now clear that diabetes and cardiovascular disease share common environmental and lifestyle antecedents or causal factors,[25,26] The metabolic syndrome is a critical component of the common causal pathway linking CVD and type 2 diabetes. The findings in this paper emphasise the scale of the challenge we face both in clinical practice and population health to contain the epidemic of CVD and type 2 diabetes. We now have evidence from intervention studies of the effectiveness of diet and exercise in the prevention of the metabolic syndrome,[5] and type 2 diabetes in high risk subjects,[27-29]. There is a need for greater awareness of the metabolic syndrome in clinical practice to provide a focus for counselling on weight loss and exercise combined with appropriate pharmacological intervention, including anti-hypertensive and lipid lowering therapy. Ultimately we will need to consider broader societal level measures to tackle this problem, in particular measures designed to reduce calorie intake and promote higher levels of physical activity.

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