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Original Research

Body mass index, waist circumference, waist–hip ratio, waist–height ratio and risk for type 2 diabetes in women: A case–control study

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SUMMARY

Objective: To assess the relationship between various anthropometric indexes and risk for type 2 diabetes in women.
Study design and methods: A case–control study of 168 cases with newly diagnosed type 2 diabetes and 336 controls who were free of the disease. Cases and controls (ratio 1:2) were matched by age (±5 years). A questionnaire was used to collect information on possible risk factors for type 2 diabetes. Odds ratios (OR) and 95% confidence intervals (CI) for type 2 diabetes were calculated by conditional logistic regression.
Results: After adjustment for possible confounders, increased risk for type 2 diabetes was associated with body mass index (BMI) ≥30 kg/m^2(OR 4.68, 95% CI 2.09–10.49), waist circumference (WC) >88 cm (OR 6.99, 95% CI 1.60–30.42)and waist–height ratio (WHtR) ≥0.5 (OR 3.15, 95% CI 1.91–15.81).
Conclusions: Both general and central obesity are associated with type 2 diabetes. The results suggest that high BMI, WC and WHtR are significant risk factors for type 2 diabetes in women.

Introduction

Diabetes is a major public health issue. In 2011, the estimated prevalence of diabetes was 366 million, representing 8.5% of the world's adult population, and it has been predicted that the number of people with diabetes will have risen to 552 million by 2030.[1] Type 2 diabetes is far more common than type 1 diabetes, and accounts for 85–95% of all people with diabetes.[2]

Lithuania, located on the south-east coast of the Baltic Sea, has an area of 65,200 km^2 and an estimated population (2011) of 3,349,872.[3] In Lithuania, the prevalence of type 2 diabetes among adults aged 35–64 years increased from 2.30% in 1987[4] to 5.00% in 2004.[5]

The number of individuals with type 2 diabetes is increasing rapidly in both developed and developing countries worldwide. The combined effects of population ageing, urbanization, rising levels of obesity and physical inactivity are driving the emerging pandemic of type 2 diabetes.[6] Excess body weight is the sixth most important risk factor contributing to the overall burden of disease worldwide. More than 1 billion adults and 10% of children are now classified as overweight or obese.[7]

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The prevalence of obesity has tripled in the last two decades and has now reached epidemic proportions.[8] In European countries, the prevalence of overweight ranges between 28% and 78% in women.[8] A random selected cohort study in Lithuania found that 33.7% of women aged 20–70 years were overweight and 14.2% were obese.[9]

Overweight and obesity are related to approximately 80% of cases of type 2 diabetes, 35% of cases of ischaemic heart disease and 55% of cases of hypertensive disease, and cause more than 1 million deaths and 12 million life-years of ill health each year among adults in the World Health Organization (WHO) European region.[8] Type 2 diabetes appears to involve interplay between susceptible genetic backgrounds and environmental factors, including highly calorific westernized diets.[10] Obesity provoke the epidemic of type 2 diabetes mellitus in developed and developing countries.[6,11]

Body mass index (BMI) is a common measure for general obesity, and is described as an independent predictor of type 2 diabetes in both genders.[12] Waist circumference (WC), waist–hip ratio (WHR) and waist–height ratio (WHtR) are used as measures of central obesity, and also provide information on risk for type 2 diabetes.[13–15] However, it is not known which anthropometric index is most suitable for assessment of the risk for type 2 diabetes in women. Therefore, the aim of this study was to assess the relationship between anthropometric indexes and risk for type 2 diabetes in women.

Subjects and methods

A case–control study was undertaken at an outpatient clinic in Kaunas, Lithuania. The study included 168 cases aged 34–85 years with newly diagnosed type 2 diabetes, according to WHO criteria,[16] between 1 January 2001 and 31 December 2001. Three hundred and thirty-six controls, without impaired fasting glucose levels or type 2 diabetes, were individually matched to the diabetic patients by 5-year age group. The ratio of cases to controls was 1:2. Information on age, gender, family history of diabetes, education, occupational and marital status, nutrition habits, alcohol consumption, cigarette smoking, physical activity and stress level was assessed using a questionnaire designed by the research group. All subjects were invited to self-complete the questionnaire. If they were unable to do so (bad general condition, poor eyesight, pathology of upper extremities or personal wish for assistance to complete the questionnaire), they were interviewed by a trained interviewer. Interviewers were not aware of the study hypothesis.

Participants were asked to fast for 12 h and to avoid smoking and heavy physical activity for at least 2 h before the examination. In accordance with WHO guidelines,[17] a single investigator took all the anthropometric measurements.

Height and weight were measured twice. Height without shoes was measured in centimetres (accuracy 0.1 cm). Weight in light clothing was measured in kilograms (0.5 kg accuracy). BMI was calculated as weight (kg)/height $(m)^2$.[18] WC was measured by holding a non-stretchable tape measure snugly around the waist, defined as the midpoint between the bottom rib and tip of the hipbones, and hip circumference was measured at the level of the great femur trochanter in centimetres (0.1 cm accuracy). WHR was defined as WC (cm) divided by hip circumference (cm), and WHtR was defined as WC (cm) divided by height (cm).[19,20]

>Blood pressure was measured twice in the right arm with the subject in a sitting position. A mercurial sphygmomanometer was used with 2.0 mm mercurial column accuracy. Blood pressure was classified as normal or hypertensive (systolic blood pressure $\geq$140 mmHg and/or diastolic blood pressure $\geq$90 mmHg and/or receiving current medication for hypertension).

Laboratory blood tests included fasting blood samples drawn from the subject's elbow vein and venous plasma samples analysed for glucose and triglyceride (TG) levels. Venous plasma glucose was estimated by the Glucose oxidase phenol 4-aminoantipyrine (GOD-PAP) method (Eppendorf analyser, Hamburg, Germany). According to the 1999 WHO recommendations,[19] 75 g oral glucose tolerance tests were performed to assess carbohydrate disorders. TG was estimated by the Glycerol-3-phosphate oxidase phenol+aminophenazone (GPO-PAP) method (Randox analyser, London, United Kingdom).

BMI was categorized as 18.5–24.9 kg/m^2, 25–29.9 kg/m^2 or $\geq$30 kg/m^2 [21]; WC was categorized as<80 cm, 80–88 cm or >88 cm[22]; WHR was categorized as $\leq$0.85 or >0.85; and WHtR was categorized as <0.5 or $\geq$0.5. Family history of diabetes was categorized as first-degree relatives with history of diabetes or first-degree relatives without history of diabetes. Education was categorized as $\leq$10 years, 11–13 years or$\geq$14 years. Marital status was categorized as married/living together, divorced/separated, single and widowed. Dietary habits were assessed according to eating speed (slower, the same or faster compared with others); food portion (smaller, the same or larger compared with others), and enjoyment of salty and fatty food (like very much, like or do not like). Morning exercise for at least 30 min during the last 12 months was categorized as no, sometimes or yes. Arterial hypertension was categorized as yes or no, and finally, plasma TG was categorized as <1.7 mmol/l or $\geq$1.7 mmol/l.

A conditional logistic regression was used to calculate odds ratios (OR) and corresponding 95% confidence intervals (CI) for diabetes in relation to the exposures of interest. Variables were retained in models as confounders when their inclusion changed the value of the OR by more than 10% in any exposure category.

All reported trend test significance levels (*P*-values) were two-sided.[23] Chi-squared test was used to calculate the difference between proportions. The level of significance was set at 5%. All calculations were performed using STATA Version 7 (StataCorp LP, Texas, USA).

Results

Table 1 shows the characteristics of the cases and controls. The cases had significantly lower levels of education and higher BMIs compared with controls. More controls reported no family history of diabetes compared with cases.

General obesity was assessed using BMI, and central obesity was assessed using WC and WHR. Univariate regression showed that overweight and obesity were associated