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# Multiple anthropometric measures in relation to incidence of diabetes: a Swedish population-based cohort study

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## Abstract

Background: Obesity is the major modifiable risk factor for diabetes. This study investigated the incidence of diabetes in relation to multiple anthropometric measures.

Methods: Body mass index (BMI), waist circumference (WC), waist-height ratio (WHtR), waist-hip ratio (WHR) and body fat percentage (BF %) were measured among 26604 subjects (aged 45-73 years) without history of diabetes from the Malmö Diet and Cancer cohort.

Results: During 14 years of follow-up, 2935 subjects (1519 men, 1416 women) were diagnosed with diabetes. In men, incidence of diabetes was 24.1 and 4.0 per 1000 person-years comparing the 4th vs 1st quartile of WHtR. The multivariate adjusted hazard ratios (HR; 4th vs 1st quartile) were 6.00 (95%Cl: 5.02-7.16) for WHtR, 5.95 (CI: 4.96-7.14) for WC, 5.19 (CI: 4.38-6.15) for BMI, 4.71 (CI: 3.96-5.60) for WHR and 3.21 (CI: 2.75-3.76) for BF%. For women, incidence of diabetes was 15.1 and 1.4 per 1000 person-years for 4th vs 1st quartile of WHtR (HR: 10.19, CI: 8.10-12.82). HR was 9.16 (CI: 7.40-11.33) for WC, 6.42 (CI: 5.27-7.81) for BMI, 6.75 (CI: 5.52-8.25) for WHR and 5.39 (CI: 4.42-6.57) for BF%. Model discrimination was marginally increased when WC, WHtR or WHR was used in combination with BMI.

Conclusion: All measures of obesity were associated with substantially increased incidence of diabetes. Abdominal obesity was associated with higher incidence rates in men than in women, but in terms of relative risks the relationships were stronger in women. The combination of BMI and abdominal obesity measures had stronger association with diabetes than BMI alone.

**Keywords:** anthropometric measure, incidence of diabetes, risk factors, population-based cohort study.

## Introduction

Type 2 diabetes is an increasing health problem in most countries [1]. Age, sex and genetic factors play key roles for diabetes onset, however, diabetes is a preventable disease and obesity is the major modifiable risk factor in the population [2-5]. The relationships between obesity and blood glucose or diabetes have been demonstrated both in cross-sectional [6-8] and prospective studies [9-12].

Body mass index (BMI) is the most practical and commonly used anthropometric measure for general fat [6, 9, 10]. However, the body fat distribution, especially abdominal obesity has been proposed to be a stronger risk factor for diabetes [13, 14]. A recent meta-analysis found that waist/height ratio (WHtR) is a better screening tool for cardiometabolic risk factors compared to waist circumference and BMI [15]. Other studies suggested that both general fat and abdominal fat are risk factor for diabetes [7, 11]. Prospective data on anthropometry and incidence of self-reported diabetes have been reported in a study from Germany. WC was a better predictor than other measures among men and women; WHtR improved the prediction most for men and WHtR and WC were similar predictors for women [12]. Most studies of obesity and incidence of diabetes have been performed in populations from Europe [9, 11, 12] or the US [4, 6]. However, cross-sectional analyses from the Obesity in Asia Collaboration, including more than 263 000 individuals from 21 studies, reported stronger relationships for waist circumference and type 2 diabetes than for BMI[8].

The aim of this prospective study was to explore the relationship between different anthropometric measures, i.e., BMI, WC, WHtR, waist-hip ratio (WHR) or percent body fat (BF%), and incidence of diabetes in a large population-based cohort study.

## Materials/subjects and Methods

### Study population

Malmö Diet and Cancer (MDC) cohort, from the city of Malmö in southern Sweden, was used for the present study. All women born between 1923 and 1950 and men born between 1923 and 1945 living in Malmö city were invited to the MDC study during the period March 1991 to September 1996, participant rate was 41% [16-18]. A total of 28 449 subjects underwent measurement of blood pressure and anthropometric measures and filled out a self-administered questionnaire.

Subjects with history of diabetes (n= 958) at the baseline examination were excluded. In addition, 887 subjects were also excluded due to missing values of anthropometric measurements and other biological, life-style and socioeconomic variables. Thus, the final study population in the project consisted of 26 604 subjects (10 332 men (38.8%) and 16 272 women (61.2%)), aged 45-73 years.

The ethics committee at Lund University approved the study (LU 51/90) and all participants provided informed consent.

### Baseline examinations

The examinations were performed by trained nurses at the screening center. Standing height was measured with a fixed stadiometer calibrated in centimeters. Weight was measured to the nearest 0.1 kg using balance-beam scale with subjects wearing light clothing and no shoes. BMI was calculated as weight (kg) divided by the square of the height ($m^2$). WC was measured as the circumference (cm) between the lowest rib margin and iliac crest and hip circumference (cm) as the largest circumference between waist and thighs. WHR was defined as the ratio of circumference of waist to hip. WHtR was defined as the ratio of circumference of waist to height. Bioelectrical Impedance Analyzers (BIA) was used for estimating body composition and BF% was calculated using an algorithm, according to procedures provided by the manufacturer (BIA 103, JRL systems, single-frequency analyzer, Detroit, USA) [19]. BMI, WC, WHtR, WHR and BF % was categorized into quartiles Q1–4, separately for men and women.

Information on current use of lipid-lowering or anti-diabetic medications, smoking habits, alcohol consumption, leisure-time physical activity, education level, civil status and immigrant status were obtained from a self-administered questionnaire. Low level of leisure-time physical activity was defined as the lowest tertile of a score revealed through 18 questions covering a range of activities in the 4 seasons. The evaluation of the questionnaire has been previously reported [20]. Subjects were categorized into current smokers (i.e. those who smoked regularly or occasionally) or non-smokers (i.e. former smokers and never smokers). High alcohol consumption was defined as >40 g alcohol per day for men and >30 g per day for women. Education was divided into three groups: school year <9, 9-12 and > 12, respectively. Civil status was categorized into married or not. Immigrant status was grouped as Swedish-born and foreign-born.

*Incidence of diabetes*

All subjects were followed from the baseline examination until first diagnosis of diabetes, death, emigration from Sweden or December 31st, 2009, whichever came first. A total of 5117 subjects were censored from the cohort due to death (n=4912) or emigration from Sweden (n=205). New-onset cases of diabetes in the MDC cohort were retrieved from several sources and have been described in detail previously [21, 22]. In short, incident diabetes was identified in the Malmö HbA1c register (MHR) (56% of all cases), the Swedish National Diabetes Register

(NDR) (14%), the Swedish inpatient register (40%), the Swedish outpatient register (38%), the nationwide Swedish drug prescription register (65%), the regional Diabetes 2000 register of the Skåne region (22%). Of 113 cases (3.8%) that had diabetes as cause of death all except three were also found in other registers. In addition, 44% of the cases were identified at re-examinations of the cohort. At least two independent sources confirmed the diagnosis for 71.6 % of the cases, and 53% of the cases were identified in three independent data sources. NDR and the Diabetes 2000 register required a physician diagnosis according to established diagnostic criteria (fasting plasma glucose concentration of >=7.0 mmol/L, which corresponds to a fasting whole blood glucose of >=6.1 mmol/L, measured on 2 different occasions). The MHR at the Department of Clinical Chemistry, Malmö University Hospital, analyzed and recorded all HbA1c samples taken in institutional and non-institutional care in the greater Malmö area from 1988 onwards. Individuals who had at least two HbA1c recordings >=6.0% in the MHR with the Swedish Mono-S standardization system (corresponding to 7.0% according to the US National Glycohemoglobin Standardization Program) after the baseline examination were defined as incident diabetes cases.

**Statistical analysis**

Cox proportional hazards regression was used to examine the association between anthropometric measures (in quartiles) and incidence of diabetes. Time axis was follow-up time until death, emigration, incident diabetes or end of follow-up. Hazard ratios (HR), with 95% confidence interval (CI) were calculated. Age was included as covariate in the basic model. Multivariable Cox proportional hazards models were adjusted for use of lipid-lowering medication, current smoking, high alcohol consumption, low leisure physical activity, low education, marital status and immigrant status. We calculated the Harrell's C-statistic to assess whether the anthropometric measures improved model discrimination [23, 24].

The Harrell's C statistics [25, 26], a generalization of the area under the receiver-operating characteristic (ROC) curve were calculated to assess the diabetes prediction efficiency of the models.

Interaction terms were added to the age- and sex-adjusted Cox model to explore the potential interactions between gender and quartiles of anthropometric measures. In addition we also performed analyses of incidence of diabetes in relation to anthropometric measures dichotomized according to previously suggested cut-off values [15, 27]. All analyses were performed using IBM SPSS Statistics (version 20; IBM Sweden AB, Stockholm, Sweden) and Stata software version 12.0 (StataCorp).

# Results

### Study cohort

The baseline characteristics of men and women in the MDC cohort (N=26 604) are presented in Table 1. As expected, men generally had higher levels of the anthropometric measures, except for BF%. Mean age was higher for men. Prevalence of smoking was similar in men and women.

### Incidence of diabetes in relation to anthropometric measures

During a mean follow-up of 14 years, a total of 2 935 subjects (1 519 men and 1 416 women) developed diabetes. Incidence (per 1000 person-years) was 10.8 for men and 6.1 for women. The overall analysis showed that BMI, WC, WHtR, WHR and BF % all were major risk factors for diabetes independently from several sociodemographic, lifestyle and biological factors, both among men and women. Among men, incidence of diabetes was 24 (95%CI: 22-26) vs 4.0 per 1000 person-years (CI:3.3-4.6) , comparing 4$^{th}$ vs 1$^{st}$ quartile of WHtR (Table 2). The adjusted HR of incident diabetes (4$^{th}$ vs 1$^{st}$ quartile) were 6.00 (95% Cl: 5.02-7.16) for

WHtR, 5.95 (4.96-7.14) for WC, 5.19 (4.38-6.15) for BMI, 4.71 (3.96-5.60) for WHR, and 3.21 (2.75-3.76) for BF% after adjustment for several potential confounding factors, Table 2. For women, incidence of diabetes was 15.1 (95%CI: 14-16) and 1.4 per 1000 person-years (95%CI: 1.1-1.7), respectively, for 4$^{th}$ vs 1$^{st}$ quartile of WHtR. The adjusted HR was 10.19 (8.10-12.82) for WHtR, 9.16 (7.40-11.33) for WC, 6.75 (5.52-8.25) for WHR, 5.39 (4.42-6.57) for BF% and 6.42 (5.27-7.81) for BMI, Table 3. All anthropometric measures except BMI (p=0.058) showed statistically significant interactions with gender with respect to incidence of diabetes, indicating greater HRs in women.

We also performed analyses of incidence of diabetes in relation to anthropometric measures dichotomized according to previously suggested cut-off values (BMI >30 kg/m2, WC >102 cm for men and >88 cm for women, WHR >0.9 for men and >0.85 for women and WHtR >0.52 for men and > 0.53 for women) [15, 27]. In the final multivariate model, HR was 3.61(3.22-4.03) for men and 3.43(3.06-3.85) for women for BMI; HR was 3.41 (3.07-3.80) for men and 4.07(3.64-4.54) for women for WC; HR was 2.93(2.47-3.47) for men and 3.64(3.25-4.07) for women for WHR; HR was 3.27(2.89-3.70) for men and 4.03(3.62-4.50) for women for WHtR.

### Anthropometric measures and incidence of diabetes discrimination

All anthropometric measures significantly improved model discrimination of diabetes compared to model adjusted for age only, Table 4. The C-statistics were significantly increased when WC, WHtR or WHR was added on top of BMI and age, Table 4.

## Discussion

In the present population-based cohort study, we found that all measures of obesity were associated with a substantially increased incidence of diabetes, with somewhat higher point estimates for abdominal obesity measures than for general obesity measures, i.e., BMI and BF%. The relationships were independent of measured potential confounders, including multiple biological, lifestyle, and socio-economic factors. WC, WHtR or WHR significantly improved the association with diabetes on top of BMI.

Type 2 diabetes is an increasing health problem in most countries and obesity is the major modifiable risk factor in the population. It is therefore important to identify and utilize the most appropriate measures to assess the future risk. In our study, the highest HR for diabetes was found for WHtR. This is in line with results from other studies[12, 15]. The suggested cut-off value for WHtR based on 34 analyses in 16 studies was 0.52 and 0.53 for diabetes, in men and women, respectively [15]. It has been suggested that WHtR might be a simple, more effective indicator of obesity; "keep your waist circumference to less than half your height" [28].

Abdominal obesity was associated with higher HRs in women compared to men. In women, but not in men, the confidence intervals were non-overlapping between BMI and abdominal measures of obesity. There were also significant interaction terms for WC, WHR and WHtR, indicating greater HRs of abdominal obesity in women than in men. However, in a public health perspective, incidence rates and absolute numbers of diabetes are more important measures than relative risks. With this perspective, it is important to note that incidence for men in the 4th quartile of WHtR was 24 per 1000 person-years, and the corresponding rates for women 15 per 1000 person-years. Hence, even though HRs were higher in women, the absolute risk associated with abdominal obesity still is higher in men.

It is also noteworthy that abdominal measures added information on top of BMI, which suggests that both measures could be useful in some situations, in contrast to the general obesity measures (e.g. BMI and BF%). Abdominal obesity, in terms of visceral fat tissue, which is metabolically more active than non-visceral fat, could influence the development of diabetes and increase the degree of insulin resistance [29, 30]. Inflammation in fat tissue may link between obesity and diabetes [31]. It has been shown that tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6) in obesity could alter the insulin signaling mechanism in adipose tissue and increase the susceptibility to develop insulin resistance [32, 33]. This circumstance might explain our finding that the point estimates for abdominal anthropometric measures were higher than for BMI or BF%.

**Strength and limitations**

The strength of the study was the large numbers of subjects and events during a long follow-up period. A main limitation of the present study is lack of information on type of diabetes. Since the subjects of the study were 45- 73 years old, it can be assumed that the vast majority of the incident cases developed type 2 diabetes since type 1 diabetes usually has early onset [34]. Another question is whether the study cohort was representative for the background population since the participation rate of MDC was approximately 41%. However, a previous study from the city of Malmö showed no substantial difference in basic characteristics, such as smoking and obesity, between participants in the MDC and a health survey within the Region of Skåne, Sweden, with 75% participation rate [17]. Another issue is to generalize our findings to other countries, especially non-European populations. Our study included 11.8% of foreign-born, of whom most were from European countries and less than 1% were born outside Europe. Since obesity is increasing in Sweden and in many other countries, while other cardiovascular risk factors, such as smoking and hypertension tend to decrease, the prevalence of obesity in this study is somewhat lower than in more recent studies [35-37].

Weight and height were measured by trained nurses at baseline. These measures are easy to measure and quite stable over time and it can be assumed that measurement errors were small. However, the impedance measurements in this study showed weaker associations with incidence of diabetes. We cannot rule out that lower precision of the bio-impedance measures, as compared to other anthropometric measures, could explain the lower HRs.

New cases of diabetes were identified from several national and local data sources [38, 39]. The coverage of the registers is very good. Many cases were detected during re-examinations of the MDC cohort. However, diabetes can often go undetected for a long time before seeking medical care and cases that did not seek medical care might have been missed.

Change in exposure is an inherent problem in long-term cohort studies. We lack information on anthropometric measures during the follow-up. It is possible that body fat distribution in some cases changed during the 14 years follow-up. However, this is usually slow process [40] and, if anything weight changes should bias the estimates towards null.

## Conclusions

In conclusion, all anthropometric measures of obesity were associated with a substantially increased incidence of diabetes. Abdominal obesity was associated with higher incidence rates of diabetes in men, but in terms of relative risks the relationships were stronger in women. The combination of BMI and abdominal obesity measures had stronger association with diabetes than BMI alone.

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Skåne University Hospital and the Lundströms Foundation.

**Conflict of interest**

The authors declare no conflict of interest.

**Key points**

- All anthropometric measures of obesity were associated with a substantially increased incidence of diabetes, with higher point estimates for WHtR or WC than for BMI and BF%.
- Abdominal obesity was associated with higher incidence rates of diabetes in men than in women, but in terms of relative risks the relationships were stronger in women.
- The combination of BMI and abdominal obesity measures had stronger association with diabetes than BMI alone.

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Table 1. Baseline characteristics of the Malmö Diet and Cancer cohort (N=26 604).

| **MDC** (N=26 604) | **Men** (n=10 332) | **Women** (n=16 272) |
|---|---|---|
| Age at screening (years) | 59.1±7.1 | 57.3±7.9 |
| BMI, body mass index (BMI) | 26.2±3.4 | 25.3±4.1 |
| Waist circumference (cm) | 93.4±9.9 | 77.5±10.2 |
| Waist-height ratio (WHtR) | 0.53±0.1 | 0.47±0.1 |
| Waist-hip ratio (WHR) | 0.94±0.1 | 0.79±0.1 |
| Body fat percentage (BF %) | 20.7±4.9 | 30.7±4.9 |
| Lipid-lowing medication (%) | 4.3 | 1.8 |
| Current smoker (%) | 28.8 | 28.1 |
| High alcohol consumption (%) | 7.4 | 2.4 |
| Low physical activity (%) | 23.9 | 24.1 |
| Married (%) | 72.7 | 60.6 |
| Low education (%) | 45.8 | 39.0 |
| Immigrant status | | |
| Other European countries (%) | 11.1 | 11.3 |
| Non-European countries (%) | 0.9 | 0.4 |

Values are means ± SD, unless stated otherwise.

MDC, Malmö Diet and Cancer.

Table 2: Incident diabetes in relation to different anthropometric measures among men in the MDC cohort (N=10 332).

| | Q1 | Q2 | Q3 | Q4 | *p* for trend |
|---|---|---|---|---|---|
| **BMI (n)** | 2583 | 2587 | 2583 | 2577 | |
| Range, kg/m$^2$ | 13.9-23.9 | 23.9-25.9 | 25.9-28.1 | >28.1 | |
| Diabetes, n (per 1000 p-y) | 170 (4.7) | 228 (6.2) | 376 (10.7) | 745 (23.7) | |
| HR[1] | 1.00 | 1.32(1.08-1.61) | 2.30(1.92-2.75) | 5.23(4.43-6.18) | <0.001 |
| Adjusted HR[2] | 1.00 | 1.32(1.09-1.62) | 2.33(1.94-2.80) | 5.19(4.38-6.15) | <0.001 |
| **WC (n)** | 2448 | 2631 | 2749 | 2504 | |
| Range, cm | 62-86 | 87-92 | 93-99 | >99 | |
| Diabetes, n (per 1000 p-y) | 141 (4.0) | 267(7.2) | 396(10.5) | 715(23.8) | |
| HR [1] | 1.00 | 1.79(1.46-2.20) | 2.64(2.18-3.20) | 6.13(5.12-7.35) | <0.001 |
| Adjusted HR[2] | 1.00 | 1.79(1.46-2.20) | 2.61(2.16-3.17) | 5.95(4.96-7.14) | <0.001 |
| **WHtR (n)** | 2590 | 2585 | 2570 | 2585 | |
| Range | 0.36-0.49 | 0.49-0.53 | 0.53-0.56 | >0.56 | |
| Diabetes, n (per 1000 p-y) | 151 (4.0) | 238 (6.5) | 387 (11.1) | 743 (24.1) | |
| HR [1] | 1.00 | 1.60(1.31-1.97) | 2.78(2.30-3.36) | 6.24(5.25-7.44) | <0.001 |
| Adjusted HR[2] | 1.00 | 1.59(1.30-1.95) | 2.74(2.27-3.81) | 6.00(5.02-7.16) | <0.001 |
| **WHR (n)** | 2589 | 2582 | 2588 | 2571 | |
| Range | 0.65-0.90 | 0.90-0.94 | 0.94-0.98 | >0.98 | |
| Diabetes, n (per 1000 p-y) | 162 (4.4) | 297 (8.3) | 394 (11.2) | 666 (20.9) | |
| HR [1] | 1.00 | 1.91 (1.57-3.31) | 2.59(2.16-3.12) | 5.00(4.21-5.93) | <0.001 |
| Adjusted HR[2] | 1.00 | 1.87 (1.54-2.26) | 2.51(2.09-3.01) | 4.71(3.96-5.60) | <0.001 |
| **BF % (n)** | 2734 | 2639 | 2375 | 2582 | |
| Range, % | 6-17 | 18-20 | 21-23 | >24 | |
| Diabetes, n (per 1000 p-y) | 215 (5.6) | 323 (8.7) | 385 (11.9) | 596 (18.5) | |
| HR [1] | 1.00 | 1.57(1.32-1.87) | 2.15(1.82-2.54) | 3.38(2.89-3.95) | <0.001 |

| | | | | | |
|---|---|---|---|---|---|
| Adjusted HR[2] | 1.00 | 1.54(1.30-1.84) | 2.08(1.76-2.46) | 3.21(2.75-3.76) | <0.001 |

HR [1] hazard ratio adjusted for age.

HR[2] adjusted for age, use of lipid-lowering medications, current smoking, high alcohol consumption, low leisure time physical activity, low education, marital status, and immigrant status.

Cl, confidence interval. p-y, person-years; BMI, body mass index; WC, waist circumference; WHtR, waist-height ratio; WHR, waist-hip ratio; BF %, body fat percentage. MDC, Malmö Diet and Cancer.

Table 3: Incident diabetes in relation to different anthropometric measures among women in the MDC cohort (N=16 272).

| | **Q1** | **Q2** | **Q3** | **Q4** | *p* for trend |
|---|---|---|---|---|---|
| **BMI (n)** | 4058 | 4090 | 4067 | 4057 | |
| Range, kg/m$^2$ | 14.0-22.4 | 22.4-24.6 | 24.6-27.5 | >27.5 | |
| Diabetes, n (per 1000 p-y) | 120 (2.0) | 196 (3.3) | 346 (5.9) | 754 (13.8) | |
| HR[1] | 1.00 | 1.59(1.27-2.00) | 2.83(2.30-3.49) | 6.67(5.50-8.10) | <0.001 |
| Adjusted HR[2] | 1.00 | 1.60(1.27-2.01) | 2.81(2.28-3.47) | 6.42(5.27-7.81) | <0.001 |
| **WC (n)** | 4344 | 3545 | 4531 | 3852 | |
| Range, cm | 50-70 | 71-75 | 76-83 | >84 | |
| Diabetes, n (per 1000 p-y) | 98(1.5) | 170(3.2) | 373(5.7) | 775(15.2) | |
| HR [1] | 1.00 | 2.09(1.63-2.68) | 3.67(2.94-4.59) | 9.76(7.90-12.06) | <0.001 |
| Adjusted HR[2] | 1.00 | 2.06(1.60-2.64) | 3.56(2.84-4.45) | 9.16(7.40-11.33) | <0.001 |
| **WHtR (n)** | 4075 | 4060 | 4076 | 4061 | |
| Range | 0.30-0.43 | 0.43-0.46 | 0.46-0.51 | >0.51 | |
| Diabetes, n (per 1000 p-y) | 84 (1.4) | 181 (3.0) | 340 (5.8) | 811 (15.1) | |
| HR [1] | 1.00 | 2.15(1.66-2.72) | 4.12(3.24-5.24) | 10.83(8.63-13.59) | <0.001 |
| Adjusted HR[2] | 1.00 | 2.11(1.63-2.73) | 3.98(3.13-5.06) | 10.19(8.10-12.82) | <0.001 |
| **WHR (n)** | 4073 | 4073 | 4068 | 4058 | |
| Range | 0.52-0.76 | 0.76-0.79 | 0.79-0.82 | >0.82 | |
| Diabetes, n (per 1000 p-y) | 111 (1.8) | 250 (4.2) | 351 (5.9) | 704 (13.0) | |
| HR [1] | 1.00 | 2.37 (1.90-2.97) | 3.37(2.72-4.17) | 7.29(5.96-8.90) | <0.001 |
| Adjusted HR[2] | 1.00 | 2.32 (1.86-2.91) | 3.25(2.62-4.02) | 6.75(5.52-8.25) | <0.001 |
| **BF % (n)** | 4111 | 3615 | 4927 | 3619 | |
| Range, % | 8-27 | 28-30 | 31-34 | 35-49 | |
| Diabetes, n (per 1000 p-y) | 125 (2.1) | 181 (3.4) | 481 (6.8) | 629 (12.7) | |
| HR [1] | 1.00 | 1.58(1.26-1.99) | 3.09(2.54-3.77) | 5.75(4.73-6.98) | <0.001 |

| | | | | | |
|---|---|---|---|---|---|
| Adjusted HR[2] | 1.00 | 1.57(1.25-1.98) | 2.98(2.44-3.64) | 5.39(4.42-6.57) | <0.001 |

Hazard ratio (HR) [1] adjusted for age.

HR[2] age, use of lipid-lowering medications, current smoking, high alcohol consumption, low leisure time physical activity, low education, marital status, and immigrant status.

Cl, confidence interval. p-y, person-years; BMI, body mass index; WC, waist circumference; WHtR, waist-height ratio; WHR, waist-hip ratio; BF %, body fat percentage. MDC, Malmö Diet and Cancer.

Table 4. Model discrimination (Harrell's C statistic) with anthropometric measure added to age in a Cox regression model.

| | Men | | Women | |
|---|---|---|---|---|
| | C-statistic (CI) | ΔC | C-statistic (CI) | ΔC |
| Age | 0.5278 (0.5137-0.5419) | | 0.5823 (0.5675-0.5971) | |
| Age+ BMI | 0.6828 (0.6705-0.6972) | 0.1550* | 0.7116 (0.6985-0.7247) | 0.1293* |
| Age + WC | 0.6817 (0.6686-0.6948) | 0.1539* | 0.7333 (0.7208-0.7458) | 0.1510* |
| Age + WHtR | 0.6874 (0.6740-0.7007) | 0.1596* | 0.7366 (0.7244-0.7488) | 0.1543* |
| Age + WHR | 0.6630 (0.6498-0.6762) | 0.1352* | 0.7079 (0.6949-0.7210) | 0.1256* |
| Age + BF% | 0.6314 (0.6175-0.6453) | 0.1036* | 0.6893 (0.6759-0.7026) | 0.1070* |
| Age + BMI+WC | 0.6948 (0.6816-0.7080) | 0.1670† | 0.7365 (0.7239-0.7492) | 0.1542† |
| Age + BMI+ WHtR | 0.6986 (0.6855-0.7116) | 0.1708† | 0.7383 (0.7259-0.7508) | 0.1560† |
| Age + BMI+ WHR | 0.6978 (0.6847-0.7110) | 0.1700† | 0.7427 (0.7298-0.7556) | 0.1604† |

Cl: confidence interval. ΔC: increment in C-statistic. BMI, body mass index; WC, waist circumference; WHtR, waist-height ratio; WHR, waist-hip ratio; BF %, body fat percentage.

The significance levels are indicated as follows: *$p<0.001$compare to age. † $p<0.001$ compared to age+ BMI.