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A Pooled Analysis of Waist Circumference and Mortality in 650,000 Adults

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Abstract

Objectives: To assess the independent effect of waist circumference on mortality across the entire body mass index (BMI) range and to estimate the loss in life expectancy related to a higher waist circumference.

Patients and Methods: We pooled data from 11 prospective cohort studies with 650,386 white adults aged 20 to 83 years and enrolled from January 1, 1986, through December 31, 2000. We used proportional hazards regression to estimate hazard ratios (HRs) and 95% CIs for the association of waist circumference with mortality.

Results: During a median follow-up of 9 years (maximum, 21 years), 78,268 participants died. After accounting for age, study, BMI, smoking status, alcohol consumption, and physical activity, a strong positive linear association of waist circumference with all-cause mortality was observed for men (HR, 1.52 for waist circumferences of ≥110 vs <90 cm; 95% CI, 1.45-1.59; HR, 1.07 per 5-cm increment in waist circumference; 95% CI, 1.06-1.08) and women (HR, 1.80 for waist circumferences of ≥95 vs <70 cm; 95% CI, 1.70-1.89; HR, 1.09 per 5-cm increment in waist circumference; 95% CI, 1.08-1.09). The estimated decrease in life expectancy for highest vs lowest waist circumference was approximately 3 years for men and approximately 5 years for women. The HR per 5-cm increment in waist circumference was similar for both sexes at all BMI levels from 20 to 50 kg/m^2, but it was higher at younger ages, higher for longer follow-up, and lower among male current smokers. The associations were stronger for heart and respiratory disease mortality than for cancer.

Conclusions: In white adults, higher waist circumference was positively associated with higher mortality at all levels of BMI from 20 to 50 kg/m^2. Waist circumference should be assessed in combination with BMI, even for those in the normal BMI range, as part of risk assessment for obesity-related premature mortality.

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Increasing obesity, including central obesity, poses a major clinical and public health challenge because of elevated disease risks and premature mortality. Obesity is most commonly measured using body mass index (BMI), defined as weight in kilograms divided by the square of height in meters. Obese individuals (BMI, ≥30.0 kg/m^2) have higher all-cause mortality than persons with normal BMI (BMI, 18.5-24.9 kg/m^2).[1-6] However, in studies observing this association, lower BMI is also associated with higher mortality, resulting in a J- or U-shaped risk curve. The shape of the BMI and mortality curve is explained in part by confounding due to tobacco use, preexisting illness, recent weight loss, or short duration of follow-up.[5] In addition, use of BMI as a measure of obesity has important limitations because BMI does not discriminate fat from lean mass or abdominal from gluteofemoral fat, both of which have different health implications.[7] This limitation partly explains the imperfect diagnostic accuracy of BMI in identifying individuals with excess body fat, particularly in the BMI range of 25 to 29.9 kg/m^2 and among men and elderly populations.[8]

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Waist circumference strongly correlates with abdominal obesity and is the most commonly used clinical measure of body fat distribution.[7,9] Waist circumference has been positively associated with all-cause mortality in most studies,[3,10-17] with only a few exceptions.[18,19] Abdominal obesity appears to be more strongly associated with multiple chronic diseases than is gluteofemoral obesity, likely through adverse metabolic effects (eg, decreased glucose tolerance, reduced insulin sensitivity, and adverse lipid profiles) of visceral relative to subcutaneous fat.[7,9,20]

The US Preventive Services Task Force[21] recommends screening for obesity on the basis of a BMI of 30 kg/m^2 or higher, whereas the National Institutes of Health[22] recommends only measuring waist circumference in people whose BMI is in the overweight (BMI, 25.0-29.9 kg/m^2) or class I obesity (BMI, 30.0-34.9 kg/m^2) range, using clinically defined cut points of 102 cm for men and 88 cm for women to define elevated risk. However, measurement of waist circumference is not recommended for underweight (BMI, <18.5 kg/m^2), normal weight (BMI, 18.5-24.9 kg/m^2), or grades II to III obesity (BMI, ≥35.0 kg/m^2), although increased waist circumference has been noted to possibly be a risk marker in persons of normal weight.[22] Because of the high correlation between BMI and waist circumference, it has been difficult for even the largest studies[3,16,17] to model the effect of waist circumference on mortality across all categories of BMI, and even in those studies that have done this, the groupings of BMI were large. Given the established clinical utility of BMI, it is particularly important to fully understand the magnitude of risk of waist circumference within clinically meaningful categories of BMI.

To overcome these limitations, we examined the association of waist circumference with all-cause mortality in a pooled analysis of 650,000 participants from 11 prospective cohort studies. These pooled analyses included 78,000 deaths, which is 5 times larger than any individual study published to date.[3,16,17] This large sample size allowed us to (1) systematically model the association of waist circumference with mortality using clinically intuitive 5-cm (approximately 2-in) increments for men and women and (2) evaluate risk within relatively narrow bands of BMI to assess the validity of guidelines that use a single clinical cut point for waist circumference and do not recommend monitoring waist circumference in underweight, normal, or extremely obese men and women.[22] We also estimated for the first time, to our knowledge, the potential years of life lost due to a large waist circumference.

METHODS

Study Cohorts

Prospective cohort studies from the BMI and mortality pooling project[5] were eligible for this analysis. All individual studies were approved by an institutional review board, and participants provided informed consent. We excluded studies that did not collect waist circumference data within 3 years of ascertaining baseline weight; all[10,11,14,17,23-26] but 3 studies[16,27,28] collected waist circumference data at the same time as weight data. Waist circumference was measured by a technician in one study,[14] whereas in the remaining studies it was reported by participants using measurement instructions and a paper tape provided by the study. The self-reported waist circumference data were found to be valid and reliable in several studies that formally assessed it.[28-30] All variables were harmonized across cohort studies as previously described.[5]

Participants were followed up from study baseline (the year in which waist circumference was reported) to date of death, end of follow-up, or loss to follow-up. Cause of death was coded according to the *International Classification of Diseases* (9th or 10th revisions).

Statistical Analyses

We restricted the analysis to non-Hispanic white participants (on the basis of self-report of race/ethnicity) and ages 20 to 84 years at baseline. We further excluded participants with a BMI of 15.0 or less or 50.0 kg/m^2 or greater and a waist circumference of 51 cm or less or 190 cm or greater.

Waist circumference was categorized into 6 levels for men and 7 levels for women, using sex-specific 5-cm increments, with the lowest level of waist circumference as the reference group. Hazard ratios (HRs) and 95% CIs for all-cause and cause-specific mortality, stratified on study, were estimated by fitting Cox proportional hazards models with age as the underlying time metric. We adjusted for educational

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