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Waist versus weight—which matters more for mortality?[1–3]

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In 2005 a controversial study by Flegal et al (1) estimated that 26,000 deaths per year in the United States were attributable to excessive body weight, which contrasted strikingly with a previous estimate of 280,000 deaths due to excess body weight (2). Among other objections, Flegal et al were criticized for their use of body mass index (BMI)—a surrogate measure of total body fat that is calculated by dividing weight in kilograms by height in meters squared—because BMI is correlated with both body fat and lean mass and does not reflect fat distribution (3). In this issue of the Journal, Flegal and Graubard (4) address this criticism in a nationally representative study by examining 8 different measures of total body fat and body fat distribution to determine whether they yield substantively different predictions of the number of deaths attributable to excess adiposity. They found that the different anthropometric measures—including waist circumference and BMI—predicted virtually the same number of deaths attributable to excess adiposity.

Two aspects of this study deserve special comment. First, Flegal and Graubard may underestimate the proportion of deaths attributable to excess adiposity because they do not exclude persons with a history of smoking or preexisting disease. It has been argued that, to account for bias, analyses of the adiposity and mortality relation should be restricted to healthy individuals with no history of smoking because smoking and preexisting disease are negatively correlated with BMI and positively correlated with mortality (5). When such exclusions were applied to Flegal et al's 2005 study, the confidence intervals of their risk estimates were quite wide, suggesting that their study size may not have been sufficient for such an analysis. Flegal and Graubard's current study involves even fewer study participants than the 2005 analysis. Larger studies, such as the ongoing adiposity-mortality investigation within the International Cohort Consortium (http://epi.grants.cancer.gov/consortia/cohort.html), may be necessary to conduct these analyses with statistical precision.

Second, although this study may underestimate the relation between adiposity and mortality, the finding that measures of fat distribution and BMI predict mortality similarly is important and calls into question the view that measures of fat distribution are superior at predicting risk of death.

Recently, the notion that measures of fat distribution, particularly waist circumference, are especially important indicators of health status has gained much currency. In the recent best-seller *You: On a Diet: The Owner's Manual for Waist Management,* the authors advocate a diet plan that is based on managing waist size rather than weight because "waist circumference, not overall weight, is the most important indicator of mortality" (6). Scientific evidence seemingly corroborates this view; just a few months ago, the largest study to date on this topic reported that waist circumference is more positively associated with mortality than is BMI (7).

However, the studies that reported that waist circumference was more positively associated with mortality than BMI used statistical models that adjusted for BMI, which tends to make the association much more positive (7, 8). One potential problem with such modeling is that waist circumference and BMI are highly correlated ($r > 0.8$ in most studies), and the resulting colinearity can lead to unstable associations for each of these variables. Another problem is that models of waist circumference that adjust for both BMI and height could conflate the effects of increased waist circumference with that of decreased lean mass. Briefly, because this modeling holds both BMI and height constant, it also holds weight constant due to algebraic constraints. If weight is held constant, then an increase in waist circumference, and hence an increase in abdominal mass, necessitates a corresponding decrease in other, possibly lean, mass. Given that decreased lean mass is strongly associated with risk of mortality, the pairing of the effects of increased waist circumference with that of decreased other, possibly lean, mass complicates the interpretation of the waist circumference–mortality relation.

Flegal and Graubard (4) do not adjust their waist circumference models for BMI. When compared with results from other models that do not adjust for BMI, Flegal and Graubard finding that waist circumference and BMI predict mortality similarly is in line with previous research (7–9).

From the perspective of visceral fat biology, the similarity of the waist circumference–mortality and BMI-mortality findings from Flegal and Graubard and others is surprising. Evidence suggests that visceral fat, the fat surrounding the internal organs

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First published online February 25, 2009; doi: 10.3945/ajcn.2009.27598.

of the abdominal cavity, is especially pathogenic. A small-scale 2006 study by Kuk et al (10), in which computerized tomography was used to measure the quantity of fat in the major body depots, showed that visceral fat, but not fat in other depots, was related to premature mortality independently from total fat. If waist circumference measures visceral fat more accurately than BMI, why have studies shown that a large waist circumference predicted virtually the same risk of death as a high BMI?

One explanation may be that, at least in some study populations, waist circumference is in fact only marginally better than BMI at measuring visceral fat. For example, one recent study showed that, among women, waist and BMI are similarly correlated with visceral fat ($r = 0.78$ between waist and visceral fat and $r = 0.64$ between BMI and visceral fat) (11). More generally, waist circumference and BMI are highly correlated (eg, in Flegal and Graubard's study, $r = 0.89$ for men and 0.88 for women), suggesting that these 2 measures may be similar indexes of body composition and therefore yield similar results.

In conclusion, although Flegal and Graubard likely underestimate deaths that are attributable to excess adiposity, they are probably correct that waist is no better than weight in predicting the mortality risks related to excess adiposity. Simple anthropometric measures of fat distribution such as waist circumference may not be accurate enough in their assessment of visceral fat to answer the question of how body fat distribution relates to mortality. A more definitive answer may only be reached in the context of large-scale studies in which fat distribution is measured using computerized tomography or magnetic resonance imaging.

I would like to thank Arthur Schatzkin, Robert N Hoover, Patricia Hartge, and Victor Kipnis of the National Cancer Institute for their insightful feedback.

The author had no conflict of interest.

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