Waist Circumference Values Are Increasing Beyond Those Expected From BMI Increases

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Abstract

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Objective: The objective of this investigation was to examine the relationship between BMI and waist circumference (WC) by gender and race subgroups from U.S. population-based data from 1959 to 2004 and to investigate the trend in WC over calendar time.

Research Methods and Procedures: Demographic and anthropometric cross-sectional data on 30,730 participants 18 to 79 years old across five national surveys were included. We regressed WC on BMI while controlling for age in each time period for blacks and whites by gender.

Results: The relationship between BMI and WC as characterized by the slope of the linear regression of WC on BMI does not seem to be changing significantly over time. A small (range, 0.08 to 0.27 cm/yr) increase in WC over time was observed.

Discussion: The implications of these findings for public health and for understanding any extant changes in the BMI-mortality rate relationship remain to be elucidated.

Key words: BMI, waist circumference, gender, race

Introduction

Independently of overall adiposity, body fat distribution seems to be a risk factor for several diseases. Waist circumference (WC),[1] a marker of body fat distribution, has been linked to cardiovascular diseases (1–3), insulin resistance syndrome (4–7), and an increased risk of breast, colorectal, and renal cell cancer (8–10). WC thresholds implicated in risk for cardiovascular disease have been established as >102 and >88 cm for men and women, respectively (11,12). Recognizing the implications of abdominal adiposity, the NIH recommends that WC be measured, especially in overweight people with BMI of 25 kg/m^2 and higher (11).

Biggard et al. (13) investigated the relationship between WC and all-cause mortality after adjusting for BMI and found that WC accounted for the mortality risk associated with excess abdominal fat above and beyond body weight. In this light, it is interesting that recent evidence suggests that the association of BMI with mortality rate may have changed over calendar time (14,15). These findings invite speculation that this could be because the relationship between BMI and aspects of body composition, including body fat distribution, may have changed over calendar time. Monitoring changes in BMI and the prevalence of obesity over time is essential for evaluating strategies and actions for the prevention and management of obesity. The primary aim of the present study was to examine the relationship between BMI and WC by gender and race subgroups from population-based data over several time periods and to investigate the trend in WC over calendar time for each gender and race subgroup.

Research Methods and Procedures

Samples

We used data from five nationally representative cross-sectional surveys of the U.S. population conducted by the U.S. National Center for Health and Statistics, representing time periods from 1959 to 2004. The surveys had the same basic structure and plan and contained age, gender, race, WC, height, and weight. The five data sets were as follows.

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[1] Nonstandard abbreviations: WC, waist circumference; NHES, National Health Examination Survey of Adults; NHANES, National Health and Nutrition Examination Study.

Table 1. Results of multivariate modeling of BMI and WC controlling for age

Survey year	Intercept (95% CI)			
	Black men	**White men**	**Black women**	**White women**
NHES-I (1959 to 1962)	85.2 (84.7, 85.7)	87.7 (87.5, 87.9)	76.8 (76.3, 77.3)	75.4 (75.2, 75.6)
NHANES-III (1988 to 1994)	87.8 (87.7, 88.1)	91.6 (91.4, 91.8)	84.7 (84.4, 85.2)	84.6 (84.3, 85.1)
NHANES (1999 to 2000)	87.9 (87.6, 88.2)	92.1 (91.6, 92.6)	85.5 (84.5, 86.5)	85.0 (84.3, 85.7)
NHANES (2001 to 2002)	88.3 (87.6, 89.0)	92.5 (91.9, 93.1)	85.7 (84.3, 87.3)	85.5 (85.1, 85.9)
NHANES (2003 to 2004)	88.9 (88.4, 89.4)	92.9 (92.4, 93.4)	86.3 (85.5, 87.1)	87.1 (86.6, 87.5)
	Slope (95% CI)			
	Black men	**White men**	**Black women**	**White women**
NHES-I (1959 to 1962)	2.51 (2.37, 2.64)	2.44 (2.36, 2.52)	1.77 (1.64, 1.90)	1.87 (1.82, 1.92)
NHANES-III (1988 to 1994)	2.53 (2.48, 2.57)	2.43 (2.36, 2.48)	2.10 (2.02, 2.18)	2.19 (2.14, 2.23)
NHANES (1999 to 2000)	2.45 (2.35, 2.55)	2.45 (2.33, 2.57)	1.85 (1.74, 1.94)	2.13 (2.05, 2.19)
NHANES (2001 to 2002)	2.49 (2.36, 2.62)	2.35 (2.25, 2.45)	1.90 (1.75, 2.05)	2.09 (2.03, 2.15)
NHANES (2003 to 2004)	2.50 (2.40, 2.60)	2.49 (2.41, 2.55)	2.02 (1.92, 2.12)	2.00 (1.92, 2.08)

WC, waist circumference; CI, confidence interval; NHES, National Health Examination Survey of Adults; NHANES, National Health and Nutrition Examination Study.

National Health Examination Survey of Adults (NHES; 1959 to 1962). NHES cycle I included a national sample of ~6672 non-institutionalized adults between the ages of 18 and 79. The waist measurements were made using a steel tape applied horizontally at the natural indentation of the waistline or at a level midway between the iliac crests and the lower edge of the rib cage if no indentation was present.

The Third National Health and Nutrition Examination Study (NHANES III; 1988 to 1994). NHANES III was the seventh national survey and was based on a complex multistage probability sampling design. With ~30,818 people examined and to generate unbiased national estimates of health and nutrition characteristics, 89 survey locations were randomly divided into two sets or phases, the first consisting of 44 locations and the second 45 locations. Waist measurements were made at the natural waist midpoint between the lowest edge of the rib cage and the highest point of the iliac crest.

NHANES (1999 to 2000, 2001 to 2002, and 2003 to 2004). The three surveys were stratified multi-stage probability samples based on selection of counties, blocks, households, and persons within households. The sample design and weighting methodology across NHANES 1999 to 2004 were very similar and included 9965, 11,039, and 12,671 individuals, respectively.

Because the NHES I survey did not sample persons 79 years old and over, we included only persons 18 to 79 years of age in this study. We included only two race groups (white and black), as that allowed comparability across the surveys. Women who were designated by self-report as pregnant were excluded from the analyses.

Statistical Analysis

We regressed WC on BMI while controlling for age in each survey for each of four race-by-sex groups. BMI was centered around a value of 25 (close to but lower than the population mean) and age at 40 years to improve interpretability. Standard errors were calculated using the sample weight, strata, and primary sampling units in the SURVEYREG procedure (SAS version 9.1; SAS Institute, Inc., Cary, NC). Linear regression was used for trend analysis.

Results

Coefficients from the multivariate model of WC centered at age (40 years) and BMI (25 kg/m^2) are shown in Table 1. The intercept represents the predicted WC for an individual 40 years old with a BMI of 25 kg/m^2 within a given gender and race group. The slope represents the linearly increasing relationship between BMI and WC. Among men, white men had a significantly greater WC than black men across calendar time. WC was significantly greater in black women compared with white women in NHES I. However, from NHANES III (1988 to 1994) through NHANES (2003 to 2004), there were no significant differences in WC among women. As shown by the slope coefficients, there was no

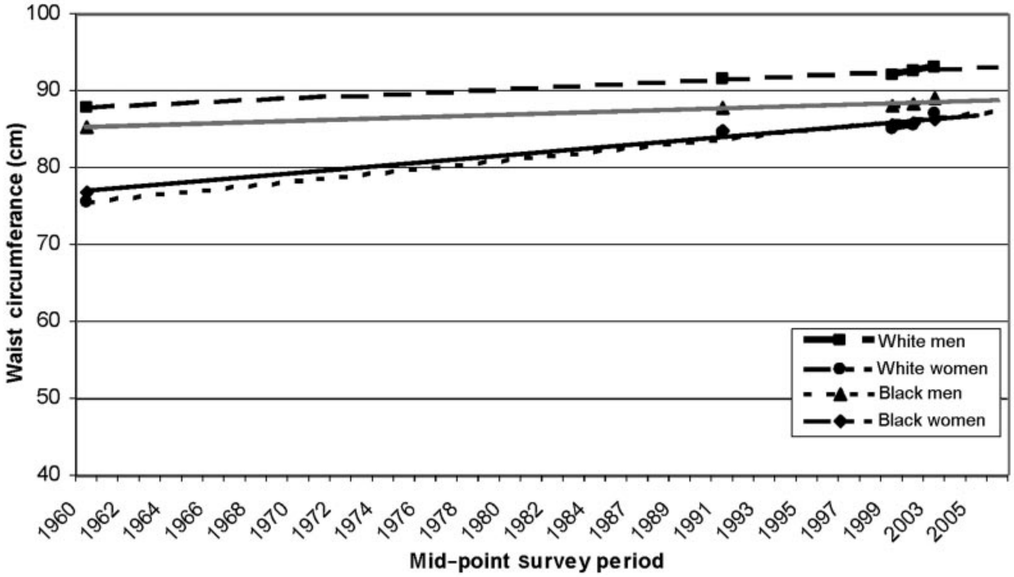

Figure 1: Predicted WC by gender and race over calendar time controlling for BMI (25 kg/m^2) and age (40 yrs).

shift in the rate of increase in the WC distribution over time for men and only a slight increase for women from NHES I to NHANES III. A trend analysis from 1959 through 2004 showed a significant increase in WC for a subject 40 years old with a BMI of 25 kg/m^2 for all race/gender subgroups (Figure 1). The linear trends were 0.13 cm/yr for white men, 0.08 cm/yr for black men, 0.27 cm/yr for white women, and 0.23 cm/yr for black women.

Discussion

The change in WC was investigated over time among U.S. adults in five national surveys between the years 1959 and 2004: NHES I (1959 to 1962), NHANES III (1988 to 1994), and NHANES (1999 to 2000, 2001 to 2002, and 2003 to 2004). Our analysis did not include the intermediate survey years, NHANES I (1971 to 1975) and NHANES II (1976 to 1980), because those surveys did not measure WC. In addition, NHES II and III, which sampled children 6 to 11 years of age and youth 12 to 17 years of age, respectively, were not included because our analysis was confined to U.S. adults. Interestingly, there was no compelling evidence that the relationship between WC and BMI as characterized by a linear slope changed dramatically over time. In women, the slopes from NHES I were significantly different from the subsequent surveys, possibly due to differences in the measurement protocol. However, the results were consistent within gender groups, suggesting that any bias in measurement should not substantially affect the results. There was evidence for small but consistent secular increases in WC over calendar time above and beyond what would be expected from BMI increases, which suggests changes in body fat distribution in the U.S. population concurrent with the obesity epidemic. Our findings are consistent with the increase in WC reported in several other studies (16–20). Despite the fact that WC measurements do not explicitly differentiate between subcutaneous fat and visceral fat, this assessment has gained support from epidemiological studies that commonly use abdominal or waist girth measured at the umbilicus or at some other point in the mid-trunk. It is plausible that the observed increases in WC reflect increases in visceral fat.

The secular changes in body fat distribution may be attributable to many factors. Keith et al. (21) investigated several potential contributors to the obesity epidemic, such as sleep deprivation, endocrine disruptors, and certain pharmaceuticals that may also impact body fat distribution. Other possibilities also exist. One motivation for the current investigation was to pursue the conjecture that recent evidence suggesting that the association of BMI with mortality rate may have lessened over calendar time might be due to a change in the relationship between BMI and WC over calendar time. Specifically, if either the slope or the intercept of the regression of WC on BMI were shown to have lessened over time, this might produce an apparently less deleterious association of BMI with mortality rate. However, our results do not support this conjecture. Nevertheless, although the changes in WC are modest, this increase toward a more atherogenic body type is reason for concern. It is well known that a higher level of WC is associated with increased health risks (11,12). Future research to monitor population levels of body fat distribution, explore causes of such changes, and seek solutions to reverse undesirable trends seems warranted.

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