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Association of Multiple Adiposity Exposures and Cardiorespiratory Fitness With All-Cause Mortality in Men: The Cooper Center Longitudinal Study

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Abstract

Objective: To examine the additive effects of an increased number of positive adiposity exposures on all-cause mortality in men before and after stratification by cardiorespiratory fitness (CRF) level.

Patients and Methods: A total of 36,836 men underwent a physical examination at the Cooper Clinic from January 1, 1971, through December 31, 2006. Exposures included body mass index, waist circumference, percentage of body fat, and CRF as determined by duration of a maximal exercise test. Participants were identified as being either obese (positive) or nonobese (negative) for each adiposity exposure and then grouped into 4 categories: group 1, negative for all adiposity exposures; group 2, positive for any 1 exposure; group 3, positive for any 2 exposures; and group 4, positive for all exposures. Then CRF was grouped as fit or unfit on the basis of the upper 80% and lower 20% of the age-standardized CRF distribution as previously reported in the Cooper Center Longitudinal Study. Hazard ratios were computed with Cox regression analysis.

Results: A total of 2294 deaths occurred during a mean ± SD of 15.5±8.1 years of follow-up. Adjusted hazard ratios across adiposity groups were 1.0 (referent), 1.05, 1.37, and 1.87 for groups 1 through 4, respectively (P for trend <.001). Mortality rates were significantly lower within each of the first 3 adiposity groups in fit compared with unfit men (P<.009 for all comparisons).

Conclusion: An increasing number of positive adiposity exposures were associated with increased mortality in men. Because moderate to high CRF attenuated mortality rates in all adiposity groups, measurement of CRF should be included for identifying men at increased risk for all-cause mortality.

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I t is well known that obesity and sedentary lifestyle are strongly associated with all-cause mortality. The current prevalence of these 2 risk factors in the United States is high. Prevalence of obesity among US men using body mass index (BMI; a measure of weight in kilograms divided by the square of height in meters) as the criterion is 35.5%,[1] whereas only an estimated 20% of US adults meet current public health guidelines for physical activity.[2] Although most studies that have examined the association of obesity with adverse health outcomes in men have used BMI as the criterion measure,[3,4] other studies have examined the effect of body fat distribution on mortality by using waist circumference (WC) measurement.[5,6] A limited number of studies have used both BMI and WC,[7] whereas even fewer studies have used percentage of body fat as an adiposity exposure.[8] Although BMI and percentage of body fat are intended to be estimates of total adiposity, the former is simply a measure of weight for height and does not distinguish lean mass from fat mass, whereas the latter estimates the fat weight component of total body weight. Although numerous studies have examined the associations between various adiposity exposures and mortality, to our knowledge, no studies have examined the additive effect of multiple adiposity exposures on all-cause mortality.

In addition to obesity, cardiorespiratory fitness (CRF) is another strong and independent predictor of all-cause,[8-10] cardiovascular,[8,11] and cancer[12] mortality. Moreover, CRF seemingly

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attenuates mortality risk in obese men.[8] A recent article[13] emphasized that although CRF is a strong predictor of CVD and total mortality, it is currently the only major risk factor that is not routinely assessed in the general or specialized clinical setting.

Data concerning the additive effects of multiple adiposity exposures on all-cause mortality are sparse, and no study has examined the additive effects of multiple measures of obesity while simultaneously considering CRF. In a study published by Lee et al,[8] the associations among percentage of body fat, waist girth, CRF, and all-cause mortality were examined in 21,925 male patients of the Cooper Clinic who were followed up for approximately 8 years. Since that time, the size of the cohort and the number of deaths has increased considerably. In the current study, we aimed to expand on the data published by Lee et al. Specifically, we wanted to examine the additive effects for combinations of clinically defined BMI, WC, and percentage of body fat exposure categories on all-cause mortality in men to test the hypothesis that individuals who are positive for an increasing number of adiposity exposures may be at greater mortality risk than men who are negative for all adiposity exposures. In addition, we wanted to examine these risks before and after stratification by CRF level.

PATIENTS AND METHODS

Study Participants and Measurements
The Cooper Center Longitudinal Study (CCLS) is an updated continuation of the previously described Aerobics Center Longitudinal Study,[9] with additional clinical measures and mortality follow-up added to the database. Briefly, the aim of the CCLS is to examine prospectively the association of health behaviors and chronic disease biomarkers to various health outcomes in men and women. Participants in the present study were 36,836 men who completed baseline examinations at the Cooper Clinic in Dallas, Texas, from January 1, 1971, through December 31, 2006. As described previously,[14] all participants were US residents, and most (approximately 90%) were white and from the middle to upper socioeconomic strata. After patients provided written informed consent, a clinical evaluation was performed, which included a physician examination, fasting blood chemistry assessment,

personal and family health history, anthropometry, resting blood pressure and electrocardiography, and a maximal graded treadmill exercise test. Height and weight were measured using a stadiometer and standard physician's scale. We categorized participants as nonobese (BMI <30) or obese (BMI ≥30). We measured WC at the level of the umbilicus directly over the skin using a cloth tape measure. We categorized participants as nonobese (WC ≤102 cm) or obese (WC >102 cm). Percentage of body fat was estimated from the sum of 7 skinfolds using the Jackson-Pollock generalized equation[15] throughout the study. Reliability estimates for similar skinfold measurements performed by experienced personnel range from 93% to 98%.[16] During the 35-year data collection period, all Cooper Clinic technicians received extensive training in body composition measurement before assessing patients. Participants were categorized as nonobese (percentage of body fat <25%) or obese (percentage of body fat ≥25%). Because percentage of body fat is seldom measured in the clinical setting, there is currently no authoritative consensus report on a cut point. However, there is some precedent for this value in the literature.[8,17-19] Henceforth, we shall refer to nonobese men as being negative and obese men as being positive for each adiposity exposure. Although we initially wished to examine all-cause mortality in 8 groups using all possible combinations of the 3 adiposity exposure categories, we could not do so because of inadequate sample size and a small number of deaths in some groups. Therefore, participants were grouped into 4 adiposity categories as follows: group 1, negative for all 3 adiposity exposures; group 2, positive for any 1 exposure; group 3, positive for any 2 exposures; and group 4, positive for all 3 exposures. We identified men with metabolic syndrome by using the Adult Treatment Panel III guidelines.[20] All examination procedures were administered by trained technicians who followed standardized measurement protocols. The CCLS undergoes annual review and approval by the institutional review board of The Cooper Institute.

As described previously,[9] CRF was determined during a maximal treadmill exercise test using the modified protocol of Balke and Ware.[21] Exercise duration from this protocol has been found to correlate highly (r=0.92) with directly measured maximal oxygen uptake