CLINICAL RESEARCH STUDY

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Addition of Cardiorespiratory Fitness Within an Obesity Risk Classification Model Identifies Men at Increased Risk of All-Cause Mortality

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ABSTRACT

OBJECTIVE: Guidelines for identification of obesity-related risk which stratify disease risk using specific combinations of body mass index and waist circumference. Whether the addition of cardiorespiratory fitness, an independent predictor of disease risk, provides better risk prediction of all-cause mortality within current body mass index and waist circumference categories is unknown. The study objective was to determine whether the addition of cardiorespiratory fitness improves prediction of all-cause mortality risk classified by the combination of body mass index and waist circumference.

METHODS: We performed a prospective observational study using data from the Aerobics Center Longitudinal Study. A total of 31,267 men (mean age, 43.9 years; standard deviation, 9.4 years) who completed a baseline medical examination between 1974 and 2002 were included. The main outcome measure was all-cause mortality. Participants were grouped using body mass index− and waist circumference−specific threshold combinations: normal body mass index: 18.5 to 24.9 kg/m^2, waist circumference threshold of 90 cm; overweight body mass index: 25.0 to 29.9 kg/m^2, waist circumference threshold of 100 cm, and obese body mass index: 30.0 to 34.9 kg/m^2, waist circumference threshold of 110 cm. Participants were classified using cardiorespiratory fitness as unfit or fit, where unfit was the lowest fifth of the age-specified distribution of maximal exercise test time on the treadmill among the entire Aerobics Center Longitudinal Study population.

RESULTS: A total of 1399 deaths occurred over a follow-up of 14.1 ± 7.4 years, for a total of 439,991 person-years of observation. Men who were unfit and had normal body mass index with waist circumference <90 cm and ≥90 cm had 95% (hazard ratio [HR], 1.95; 95% confidence interval [CI], 1.34-2.83) and 163% (HR, 2.63; 95% CI, 1.58-4.40) higher mortality risk than men who were fit, respectively (P <.05). Men who were unfit and overweight had 41% (HR, 1.41; 95% CI, 1.04-1.90) higher mortality risk with a waist circumference <100 cm (P <.05), but were at no greater risk (HR, 1.30; 95% CI, 0.92-1.84) if their waist circumference was ≥100 cm (P = .14). Men who were unfit and obese were not at increased mortality risk (HR, 1.37; 95% CI, 0.90-2.09) with a waist circumference <110 cm (P = .14), but were at 111% (HR, 2.11; 95% CI, 1.31-3.42) increased risk with a waist circumference ≥110 cm (P <.05).

CONCLUSIONS: For most of the body mass index and waist circumference categories, inclusion of cardiorespiratory fitness allowed for improved identification of men at increased mortality risk.

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Health organizations worldwide recommend that body mass index and waist circumference be combined to estimate obesity-related health risk,[1] because these measures have independent associations with all-cause mortality,[2] and the addition of waist circumference to body mass index has been shown to improve the evaluation of cardiometabolic risk,[3] cardiovascular disease, and diabetes.[4]

At present, a single 102-cm waist circumference threshold is recommended for the identification of adult white men at elevated health risk within each body mass index category.[1] The 102-cm threshold was originally intended as a replacement of body mass index measurement to identify white male adults with a body mass index of $\geq$30.0 kg/m^2.[5] Use of the 102-cm threshold classifies few individuals with normal and overweight body mass index and almost all individuals who are obese with high waist circumference based on this cut-point.[6] In response, Ardern et al[7] proposed the use of waist circumference values specific to each body mass index category to identify coronary heart disease mortality risk that were developed and cross-validated using large representative samples.

Currently, obesity risk classification models do not include cardiorespiratory fitness, a strong predictor of morbidity and mortality[8,9] independent of body mass index and waist circumference.[10-12] Cardiorespiratory fitness protects against all-cause mortality even when body mass index, waist circumference, and percent body fat are elevated.[13] In that study, Farrell et al[13] were unable to determine the effect of cardiorespiratory fitness across specific combinations of body mass index and waist circumference because of sample size limitations. Therefore, whether the addition of cardiorespiratory fitness improves prediction of mortality risk within a combined body mass index and waist circumference model has potentially important implications for obesity risk management. Should cardiorespiratory fitness improve risk prediction, practitioners would have a behavioral measure that, when used in combination with body mass index and waist circumference, may be used to improve the management of obesity-related health risk.

We classified a large cohort of men enrolled in the Aerobics Center Longitudinal Study (ACLS) according to body mass index− and waist circumference−specific thresholds and examined whether the addition of cardiorespiratory fitness improved the prediction of all-cause mortality.

CLINICAL SIGNIFICANCE

- In 31,267 men with a total of 439,991 person-years of observation, for most combinations of body mass index and waist circumference, unfit men were at substantially higher risk of all-cause mortality than fit men.
- Inclusion of cardiorespiratory fitness within current body mass index and waist circumference models substantially improves the ability of practitioners to identify men at higher mortality risk and thus improves patient management.

MATERIALS AND METHODS

Study Population

The ACLS is a prospective longitudinal study established in the 1970s to examine associations among health behaviors, risk factors for chronic disease, and morbidity and mortality.[8] The ACLS consists of patients attending the Cooper Clinic in Dallas, Texas, for preventive medical examinations. The ACLS cohort consists of predominantly white, well-educated US residents from all 50 states and from middle to upper socioeconomic stratum. Participants were aware of the purpose of the study and provided written consent. The ACLS protocol is reviewed annually by the Cooper Institute's institutional review board.

All men with body mass index measurements between 18.5 and 34.9 kg/m^2 and a complete set of baseline data were included for the current analysis. Men with a body mass index $\geq$35.0 kg/m^2 and all women were excluded because of few events within some groups for all-cause mortality. Participants were excluded on the basis of presence of cardiovascular disease or cancer at baseline or an abnormal exercise test electrocardiogram.[14] Participants with less than 1 year of follow-up or who failed to achieve 85% of age-predicted exercise test maximal heart rate were excluded.[8] With the use of these criteria, 31,267 men having completed baseline medical examinations at the Cooper Clinic between 1974 and 2002 were included in the analysis.

Data Collection

After providing written consent, patients underwent a preventive medical examination, fasted blood chemistry analysis, personal and family health history assessment, anthropometry, resting blood pressure, electrocardiography measurement, and a maximal treadmill exercise test. Cigarette smoking (current smoker or not), alcohol intake (heavy drinking defined as >14 alcoholic drinks per week), and physical inactivity (defined as no reported physical activity during the previous 3 months) were determined by self-report. Parental history of cardiovascular disease was determined from family health history.

Mortality Surveillance

Mortality follow-up occurred from the date of baseline examination to the date of death or December 31, 2003, for