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Combined Association of Cardiorespiratory Fitness and Body Fatness With Cardiometabolic Risk Factors in Older Norwegian Adults: The Generation 100 Study

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Abstract

Objective: To investigate the independent and combined associations of fitness and fatness with cardiometabolic risk factors in older Norwegian women and men.

Patients and Methods: We conducted a cross-sectional study of 505 women and 417 men aged 70 to 77 years enrolled in the Generation 100 study in Norway. Fitness was assessed as peak oxygen uptake and fatness as high body mass index (BMI; $\geq$25 kg/m^2), waist circumference (WC) of 88 cm or greater for women and 102 cm or greater for men, and percent body fat (%BF) of 35% or greater and 25% or greater for women and men, respectively. High cardiometabolic risk was defined as the presence of 2 or more of the following risk factors: elevated triglyceride level, reduced high-density lipoprotein cholesterol concentration, elevated blood pressure, and elevated fasting glucose level or pharmacological treatment of these conditions.

Results: Receiver operating characteristic curve analyses identified fitness levels of less than 25.7 and less than 30.7 mL/kg per minute in women and men, respectively, as critical thresholds for having high cardiometabolic risk. Individuals with levels below these thresholds had an adjusted odds ratio of 2.77 (95% CI, 2.09-3.66) for having high cardiometabolic risk, while high BMI, WC, and %BF had odds ratios (95% CIs) of 3.58 (2.69-4.77), 3.06 (2.29-4.10), and 3.26 (2.47-4.30), respectively. In our combined analyses, being lean did not attenuate the cardiometabolic risk associated with low fitness, and combinations of low fitness and/or high BMI, WC, or %BF cumulatively increased cardiometabolic risk.

Conclusion: Low fitness and indication of fatness were independently and cumulatively associated with poor cardiometabolic health. Our results emphasize the importance of including both physical fitness and body fatness in the assessment of cardiometabolic risk and health promotion efforts in older adults.

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Levels of physical activity (PA) and cardiorespiratory fitness (hereafter fitness) decline with age,[1,2] whereas the prevalence of overweight and obesity increases.[3] As the population ages, medical expenditures associated with inactivity and obesity are therefore expected to increase, posing serious public health challenges.[4] Cardiovascular (CV) disease (CVD) is the number one cause of death worldwide,[5] with the highest prevalence in older adults.[6] Combinations of cardiometabolic disturbances, such as dyslipidemia, elevated blood pressure (BP), and impaired glucose metabolism, have been identified as risk factors for CVD and all-cause and CVD mortality.[6]

Overweight and obesity are key contributors to the clustering of unfavorable cardiometabolic risk factor levels.[7] Given the strong and consistent evidence that higher levels of fitness are associated with a lower risk of CVD morbidity and mortality,[8-15] fitness may be a relevant factor largely affecting the deleterious association between overweight, obesity, and CV health. In this context, the "fat but fit paradigm" has been suggested, which refers to

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individuals who despite being obese have a relatively high fitness level.[7] Indeed, high fitness has been reported to attenuate most of the adverse effects of overweight and even mild obesity on all-cause and CVD mortality and morbidity.[7,8,16-21] Individuals who are fat but fit have lower mortality rates than lean but unfit individuals both in the general adult population[11-13] and in older adults.[10,14,22] However, whether high fitness can modify the deleterious association between body fatness and cardiometabolic risk factors has not been adequately addressed in older adults, and findings in the general population have been inconsistent.[16] A few studies found that low fitness and indication of fatness carry similar risks for the prevalence of metabolic syndrome[23,24] or incidence of type 2 diabetes mellitus (T2D),[25-27] whereas others found a greater magnitude of association between fatness and cardiometabolic risk factors.[28-30] However, these studies have included few individuals older than 70 years and particularly few older women. Thus, the generalizability to the older population is limited.

Most previous studies used body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) as a crude estimate of fatness, and despite its advantages,[31] it does not discriminate between body fat and lean body mass. In addition, estimated fitness or self-reported PA are commonly used as a proxy for directly measured fitness. Although fitness is associated with up to 70% of the variance in habitual PA,[32] objectively measured fitness generally results in stronger associations with health outcomes than PA.[9,15,16,33]

A better understanding of how fitness and fatness relate to other cardiometabolic risk factors has the potential to improve health promotion efforts. Accordingly, this study investigated the independent and combined associations of directly measured fitness and various indicators of body fatness with cardiometabolic risk factors in older Norwegian women and men.

PATIENTS AND METHODS

Study Population

We used baseline data from the Generation 100 study, a randomized controlled clinical trial with the main objective of investigating the effect of 5 years of exercise training on morbidity and mortality in the older adult population.[34] All inhabitants of Trondheim municipality, Norway, born between 1936 and 1942 (n=6966) were invited. A total of 1567 participants (790 women) accepted the invitation, complied with the inclusion criteria for Generation 100, and fulfilled baseline testing. Participants with known CVD or abnormal findings on electrocardiography during cardiopulmonary exercise testing (n=302), self-reported cancer during the preceding 2 years (n=24), and missing values on fitness (n=24), waist circumference (WC; n=4), percent body fat (%BF; n=5), and missing information on cardiometabolic risk factor composite score (n=286) were excluded. Overall, a total of 922 participants (505 women) were included in the current study.

The study was approved by the Regional Committee for Medical Research Ethics (REK Midt: 2013/1609) and complies with the Norwegian laws and the principles of the Declaration of Helsinki. All participants signed informed consent documents before participation.

Clinical Examination

Clinical examinations were carried out between August 22, 2012, and June 30, 2013, by trained personnel and followed standardized routines described in detail previously.[34] Briefly, body mass, %BF, visceral fat, and muscle mass were measured using bioelectrical impedance (Inbody 720, Biospace Co, Ltd); WC was measured at the uppermost border of the iliac crest around the abdomen. Gas exchange ergorespirometry (MetaMax II, Cortex Biophysik GmbH) was used to determine peak oxygen uptake (VO_{2peak}). The test protocol and equipment were identical to those used in previously published studies from our group.[34,35] Participants were breathing into an appropriately sized mask (Hans Rudolph, Inc), which was connected to the gas analyzer. Heart rate was monitored using the Accurex RS300X SD device (Polar Electro Oy). Calibration of the MetaMax II included barometric pressure (daily before testing), volume (between every test with a 3-L syringe [5530 series, Hans Rudolph, Inc]), and gas analyzer (between every fourth