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Sedentary Behavior, Cardiorespiratory Fitness, Physical Activity, and Cardiometabolic Risk in Men: The Cooper Center Longitudinal Study

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Abstract

Objective: To examine the association between sedentary behavior and cardiometabolic risk, while taking into account cardiorespiratory fitness (fitness) and physical activity.

Participants and Methods: We examined the association of sedentary behavior, physical activity, and fitness (exposure variables) to cardiometabolic biomarkers and metabolic syndrome (outcome measures) among a historic cohort (January 2, 1981, through October 16, 2012) of men. First, we estimated the association (cross-sectionally and longitudinally) of sedentary behavior along with physical activity and fitness to lipids and lipoproteins, glucose, blood pressure, and markers of adiposity, including body mass index, waist circumference, and body fat percentage. We then prospectively examined the effects of baseline sedentary time on the incidence of metabolic syndrome, while adjusting for physical activity, fitness, and other covariates in multivariate models.

Results: Multivariate analysis of baseline data revealed that in comparison with the reference group (≤9 h/wk of sedentary time), more sedentary behavior was significantly associated with a higher triglyceride level, a higher triglycerides–high-density lipoprotein cholesterol ratio, and a higher body mass index, waist circumference, and body fat percentage ($P<.05$ for trend), after adjusting for physical activity and covariates. When adjusting for fitness and covariates, prolonged sedentary time was only associated with a higher triglyceride–high-density lipoprotein cholesterol ratio ($P=.02$ for trend). Sedentary time was not associated with the incidence of metabolic syndrome in multivariate models. Longitudinal analyses revealed that a 1–metabolic equivalent increase in fitness was significantly ($P<.05$) associated with almost all biomarkers when adjusting for sedentary behavior, with little moderation observed.

Conclusion: The association between prolonged sedentary time and cardiometabolic biomarkers is markedly less pronounced when taking fitness into account. Further exploration of the effects of sedentary behavior on cardiometabolic risk is warranted in cohorts with available fitness data. Furthermore, our findings underscore the need to encourage achieving higher fitness levels through meeting physical activity guidelines to decrease disease risk factors.

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An increasing reliance on automation in the home, on the job, and in the community has resulted in a marked reduction in daily physical activity. Indeed, nationally representative data of the US population (measuring physical activity via accelerometers) reveal that less than 5% meet the recommended guidelines to achieve health benefits.[1] Furthermore, US adults are excessively sedentary, with 7.7 of their waking hours daily spent in a sitting, standing, or reclining posture.[2] In observational studies, these prolonged hours of sedentary time have been linked to increased risk of obesity, metabolic syndrome, type 2 diabetes mellitus, cardiovascular disease, some cancers, and premature death.[3-5] For example, Gardiner et al,[6] analyzing cross-sectional data from the Australian Diabetes, Obesity and Lifestyle study, determined that prolonged television viewing was associated with a 42% increased risk for metabolic syndrome. Another Australian study involving more than 200,000 adults and 621,695 person-years found that those who sat 11 hours or more daily were at 40% greater risk for all-cause mortality than those who sat less than 4 hours.[7]

Although these studies have primarily controlled for self-reported physical activity,

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none have taken into account cardiorespiratory fitness (henceforth "fitness"), which is an objective and reproducible consequence of habitual physical activity and genetics, as well as a reflection of overall physiologic health.[8,9] Despite having a genetic component,[10] fitness is sensitive to patterns of physical activity intensity, frequency, and duration.[11] Both observational studies and exercise trials have found dose-response relationships between increased physical activity and higher fitness levels.[9,11] However, to our knowledge, fitness has yet to be controlled for in the numerous studies assessing the health impact of prolonged sedentary time because these data are often not available.[12] Because fitness is linked to overall exercise volume and is an objective measure (in comparison with self-reported physical activity, which is prone to recall bias),[11] adjusting for fitness might provide a more precise representation of the sedentary behavior—metabolic risk relationship. Furthermore, because fitness is an integral component of overall physiologic health and function,[9] controlling for fitness might address some of the concerns that the association between excessive sitting and adverse health outcomes is a consequence of impaired health rather than the cause of it (ie, reverse causality).[13] Therefore, in the current study we examined the sedentary behavior—cardiometabolic risk relationship in conjunction with, and independent of, fitness and physical activity. We hypothesized that fitness will more strongly mitigate this association than self-reported physical activity. Furthermore, we explored the association between fitness and physical activity independent of cardiometabolic biomarkers, while assessing the potential effect modification of sedentary behavior.

PARTICIPANTS AND METHODS

Study Population and Design

Participants came to the Cooper Clinic (Dallas, Texas) for a preventive medical examination, enrolled in the Cooper Center Longitudinal Study (CCLS), and provided written informed consent. The CCLS is an ongoing cohort study aimed primarily at determining the relationship between lifestyle behaviors and morbidity and longevity.[14,15] In general, the CCLS cohort is comprised of well-educated, non-Hispanic whites (approximately 95%) who are self-referred to the clinic.[16] The CCLS is approved annually by the Cooper Institute Institutional Review Board, and the current study received exempt status from the University of Texas Health Science Center at Houston Institutional Review Board.

In the present study, of a total of 8549 men who provided information pertaining to sedentary behaviors in a 1982 mail survey, 6784 were excluded because (1) they did not have a preventive medicine visit at the Cooper Clinic within 1 year before or after survey completion, including maximal exercise testing and complete data on outcomes, and (2) they did not have at least one follow-up clinic visit within 10 years of the initial visit. Of those remaining, 435 men were excluded because of (1) personal history of cancer, myocardial infarction, and/or stroke, (2) personal history of diabetes and/or insulin use, (3) personal history of hypertension and/or medication use for hypertension, and (4) electrocardiographic abnormalities and/or not reaching 85% of maximal heart rate during the treadmill examination at baseline. Furthermore, 26 additional men did not provide baseline information pertaining to smoking and/or alcohol consumption on the medical history questionnaire and mail survey and therefore were not included in the analyses. Hence, a total of 1304 men were included in the primary analytic sample. In addition, a secondary analytic sample of 1269 men was examined for the metabolic syndrome analysis. These participants completed the 1982 survey and the maximal exercise examination and had 1 year or more of follow-up data; however, they did not have a history of cancer, myocardial infarction, and/or stroke or prevalent metabolic syndrome at baseline.

Subsequently, we examined the association between sedentary behavior, physical activity, and cardiorespiratory fitness (exposure variables) and cardiometabolic risk factors (outcome measures) in the primary analytic sample (N=1304). Specifically, we estimated the association of sedentary behavior along with physical activity and fitness to lipid, lipoprotein, and glucose levels, blood pressure, and markers of adiposity, including body mass index (BMI), waist circumference, and body fat percentage. We examined these associations both cross-sectionally and longitudinally. In the longitudinal analysis, all participants had at least 1