

## In Brief

Physical inactivity and low cardiorespiratory fitness increase the risk of developing type 2 diabetes and are associated with higher rates of cardiovascular disease and mortality in people with type 2 diabetes. Clinicians are encouraged to promote adoption of the consensus public health recommendation for physical activity for their sedentary and unfit patients and to stress that the benefit is improved health—not necessarily weight loss. Recent advances in behavioral intervention approaches can make clinicians more successful in helping their sedentary patients become and stay more physically active.

# The Importance of Physical Activity and Cardiorespiratory Fitness for Patients With Type 2 Diabetes

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The role of a sedentary lifestyle in the pathogenesis of type 2 diabetes has been clarified during the past 15 years. Initially, investigators conducting prospective observational studies found higher rates of type 2 diabetes in women and men who were sedentary than in their more active peers.<sup>1,2</sup> By the time of the publication of the Surgeon General's Report on Physical Activity and Health in 1996, there was compelling evidence to support a conclusion that inactivity was a cause of type 2 diabetes.<sup>3</sup> These early studies used self-report of physical activity as the exposure, and investigators reported relative risks (RR) of diabetes in sedentary people ranging from about 1.2 to 1.6, when compared to active people. These higher risks remained after controlling for potentially confounding variables such as age, BMI, family history of disease, and other clinical measures.

In this report, we review recent data on physical activity, cardiorespiratory fitness, and type 2 diabetes, with an emphasis on the interpretation and application of these findings in clinical settings. The importance of improving clinical practice in the treatment of individuals prone to develop type 2 diabetes and those who already have the disease is underscored by the rapidly

increasing prevalence of type 2 diabetes and recent data showing that 22% of adults in the United States have a related condition, the metabolic syndrome.<sup>4</sup>

## Importance of Cardiorespiratory Fitness

As briefly reviewed above, sedentary individuals are at a 1.2- to 1.6-fold higher risk than active individuals for developing type 2 diabetes. We believe that these risk estimates are actually underestimates of the effect of sedentary lifestyles on the disease. The reason is principally that physical activity is a complex behavior that is difficult to assess accurately by self-report, which was the method of evaluating the exposure in early studies. Self-report measures of physical activity are typically crude and imprecise, which leads to substantial misclassification and, in turn, to biasing study results towards the null hypothesis.

In contrast, cardiorespiratory fitness assessed by exercise testing in a laboratory is an objective and highly reliable measure. We believe that cardiorespiratory fitness is a more accurate measure of habitual physical activity in the weeks and months prior to the assessment than are self-report physical activity questionnaires.

### Cardiorespiratory Fitness and Risk of Incident Type 2 Diabetes

We evaluated cardiorespiratory fitness as a predictor of the development of impaired fasting plasma glucose (IFPG) and type 2 diabetes in a group of 8,633 men participating in the Aerobics Center Longitudinal Study (ACLS).<sup>5</sup> These men had an average age of 43.5 years (range 30–79 years) and had two clinical examinations and laboratory evaluations, with an average of 6 years between the examinations. We assessed cardiorespiratory fitness by a maximal exercise test on a treadmill. Type 2 diabetes was diagnosed by an IFPG  $\geq 126$  mg/dl. We therefore had an objective measure of both the exposure (cardiorespiratory fitness) and the outcome (type 2 diabetes), which should have resulted in low rates of misclassification and improved precision in assessing risk.

All men were free of type 2 diabetes at baseline, and 149 men developed the disease during 52,588 man-years of follow-up, for an overall incidence of 2.8 per 1,000 man-years. We observed incidence rates of 5.9, 2.7, and 1.6 per 1,000 man-years across low, moderate, and high fitness groups, respectively. This steep and significant inverse gradient of risk across fitness groups remained after statistical adjustment for numerous potential confounding variables (Figure 1).

In addition to the strong association between baseline cardiorespiratory fitness and incident type 2 diabetes,

men who declined in fitness also had a higher risk. For each 1-unit decline in maximal metabolic equivalents (MET; 1 MET = resting metabolic rate or 3.5 ml  $\cdot$  kg<sup>-1</sup>  $\cdot$  min<sup>-1</sup>) on the treadmill test, there was a 30% higher risk of developing type 2 diabetes (S.N.B., unpublished observations).

In summary, we find a strong, independent, and biologically plausible association between objectively measured cardiorespiratory fitness and risk of developing type 2 diabetes. This risk remains after adjustment for several potentially confounding variables, which is a conservative approach to the issue because several of these variables are probably in the causal pathway.

### Physical Activity for Patients With Type 2 Diabetes

Physical inactivity substantially increases risk for developing type 2 diabetes, but what is the effect of activity for patients who already have the disease? It is clear that an active and fit way of life has health benefits for virtually all individuals, and this includes most patients with type 2 diabetes.

Physical activity recommendations for patients with diabetes have been published by the American Diabetes Association and the American College of Sports Medicine.<sup>6,7</sup> These recommendations are generally consistent with the consensus public health physical activity recommendation published in the mid-1990s: all adults

should accumulate at least 30 minutes of moderately intense physical activity over the course of most, preferably all, days of the week.<sup>3,8,9</sup> Thus, three 10-minute walks a day can provide important health benefits, including for patients with type 2 diabetes.

It is not the purpose of this report to provide detailed discussions of specific physical activity recommendations, issues regarding evaluation of patients before exercise, and risks of activity such as retinopathy and neuropathy. These topics are covered in the position statements. Instead, we will focus on some often overlooked benefits of physical activity for patients with type 2 diabetes and provide some suggestions on how clinicians can provide evidence-based physical activity intervention strategies.

### Benefits of Regular Physical Activity

Regular physical activity provides the same benefits for patients with type 2 diabetes as for healthy individuals—increased fitness and function, enhanced feelings of well-being, reduced risk of depression, better weight control, and improvements in glucose control, blood pressure, and lipids.<sup>3,8,9</sup> In our experience, it is weight management that receives the most emphasis from clinicians when talking with their patients about becoming and staying more physically active. It is true that regular physical activity produces modest weight loss in most overweight people, helps prevent additional weight gain, and is most likely critical in maintaining weight loss once it has occurred. However, we do not believe that clinicians should stress weight management as the primary benefit or reason for regular physical activity (“You should get more exercise. It will help you lose weight.”)

Tying exercise recommendations to weight issues can set patients up for failure. It is clear that most overweight or obese adults are not likely to achieve and maintain some hypothetical “ideal weight” and that they are often dissatisfied with the modest 7–10% weight loss that provides many health benefits.<sup>10,11</sup> Our concern is that if patients have expectations that increased physical activity will allow them to achieve the slim figures of models and movie stars, at least in the relatively short term, they are highly likely to be disappointed, and this will lead to discontinuation of their activity program. They may feel

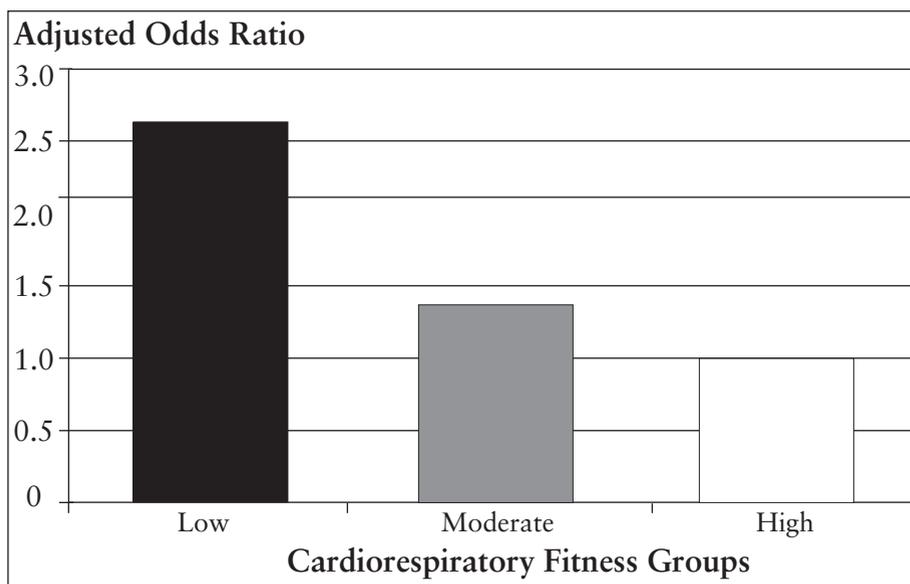


Figure 1. Odds ratios for development of type 2 diabetes in 8,633 healthy men, adjusted for age, examination year, BMI, smoking habit, alcohol intake, parental history of diabetes, and elevations in blood pressure and lipids. Adapted from Ref. 5.

that “I tried exercise, but I only lost a few pounds, and it did not seem to be worth the effort.”

We propose that the major reason for patients with type 2 diabetes to be physically active is to prevent major morbidities and to reduce the risk of mortality. This should be the primary benefit of physical activity that clinicians emphasize. (“You need to become more physically active. It will provide several health benefits, but most importantly will reduce substantially your risk of heart attack and death.”)

### Reduction in morbidity and mortality through regular physical activity

Patients with type 2 diabetes who are physically active or have moderate to high levels of cardiorespiratory fitness are much less likely than their sedentary and unfit peers to develop cardiovascular disease or to die. We evaluated risk of dying in 1,263 men with type 2 diabetes in the ACLS.<sup>12</sup> These men were 50 years of age on average and had documented type 2 diabetes determined by FPG, use of diabetes medication, or an established clinical history of diabetes. There were 180 deaths during 14,777 man-years of observation. All men completed a maximal exercise test at baseline to evaluate their cardiorespiratory fitness and were assigned to low-, moderate-, or high-fitness categories based on exercise test results. Specific cutpoints for maximal METs achieved on the treadmill test are shown in Table 1 for the three fitness categories.

We also assessed physical activity in this study by self-report on the medical history questionnaire. We classified men who reported no physical activity in the past 3 months as inactive and all others as active. The age- and examination year-adjusted risk of mortality in inactive men was 1.8 and in low-fit men was 2.9 compared to that in moderate- or high-fit men.

These data support our hypothesis that objectively measured cardiorespiratory fitness results in less misclassifi-

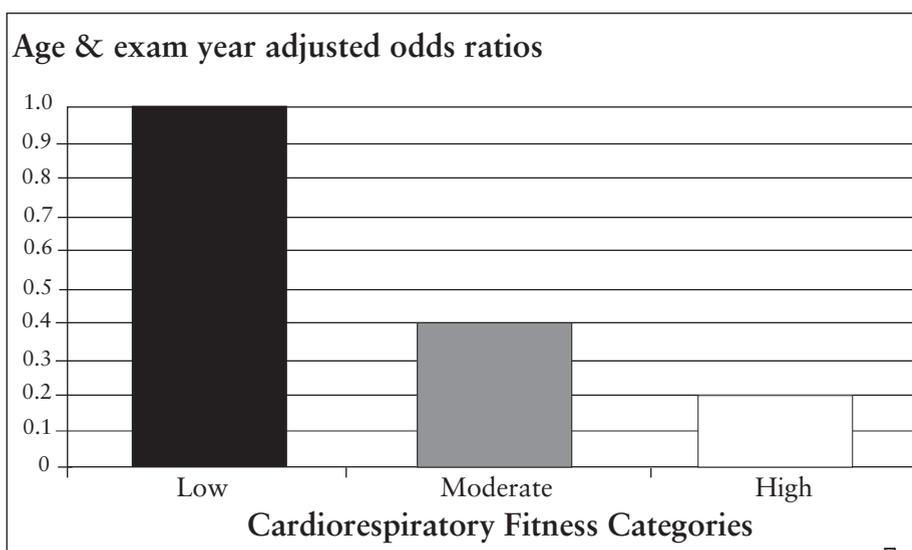


Figure 2. Age- and examination year-adjusted odds ratios for all-cause mortality across cardiorespiratory fitness categories for men in the ACLS.

cation than does self-reported physical activity, and we believe the fitness data are closer to the true association between sedentary habits and mortality risk. The protective effect of moderate-to-high fitness was evident and was comparable in overweight or obese men and in normal-weight men. Compared to fit men, unfit men had RRs of 2.8 and 2.9 for all-cause mortality in the normal weight (BMI < 25.0 kg/m<sup>2</sup>) and overweight or obese (BMI ≥ 25.0 kg/m<sup>2</sup>) men, respectively.

In additional analyses not reported in the article, we observed a steep inverse mortality gradient across fitness categories. The age- and examination year-adjusted risk of all-cause mortality across low-, moderate-, and high-fitness categories is shown in Figure 2. There is a steep inverse gradient, with the high-fit men having an 80% lower risk of dying compared to the low-fit men. This association between fitness and mortality was stronger than the association between BMI and mortality, where we observed RRs of 1.0, 1.2, and 1.3 across normal-weight, overweight, and obese categories, respectively (S.N.B., unpublished observations).

Tanasecu et al.<sup>13</sup> recently reported on the relation of physical activity to

cardiovascular disease and total mortality in men with type 2 diabetes in the Health Professionals' Follow-up Study. Study participants were 3,088 men aged 30 years or older who reported a diagnosis of diabetes. There were 266 cardiovascular events (96 of them fatal) during 18,894 man-years of observation. The investigators assessed physical activity by mail-back questionnaire and calculated total volume of physical activity in MET · hours<sup>-1</sup> · week<sup>-1</sup>.

Risk of total cardiovascular disease (fatal and nonfatal) and all-cause mortality are shown in Figure 3. The inverse gradient of risk across quintiles of total activity remained, although it was somewhat attenuated, after adjustment for characteristics such as risk factors and BMI.

In summary, we believe that the principal benefit of regular physical activity in patients with type 2 diabetes is that it protects against cardiovascular disease and all-cause mortality. Clinicians should strongly inform their patients of this benefit and tell them that this is the primary reason for becoming and staying physically active. The beneficial dose of physical activity is consistent with the consensus public health recommendation. Thus, three 10-minute walks a day can provide the benefits described herein.

### Getting Sedentary Patients to Become More Physically Active

Many clinicians have become frustrated with their inability to get patients to be physically active. The environment in our society mitigates against the routine daily activity that was required of earlier generations, and it

**Table 1. Fitness and Mortality in Men: Maximal METs Attained During Exercise Test By ACLS Fitness Category**

Fitness Group	Age Groups (Years)			
	20–39	40–49	50–59	60+
Low	≤ 10.5	≤ 9.9	≤ 8.8	≤ 7.5
Moderate	10.6–12.7	10.0–12.1	8.9–10.9	7.6–9.7
High	> 12.7	> 12.1	> 10.9	> 9.7

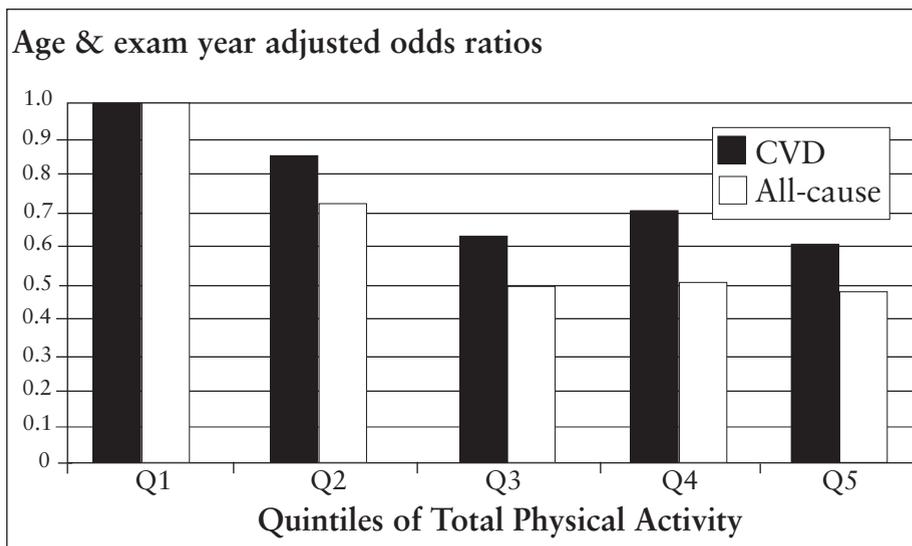


Figure 3. Age-adjusted relative risks for total cardiovascular disease (black bars [fatal + nonfatal]) and for all-cause mortality (white bars), for men in the Health Professionals' Follow-up Study. Adapted from Ref. 13.

is difficult for many individuals to overcome these environmental barriers. It is clear that efficacious physical activity interventions must involve more than simply admonishing sedentary people to become more active and giving target exercise heart rates as a prescription.

The consensus public health recommendation for physical activity and recent behavioral intervention research have provided new and more effective approaches to getting sedentary individuals to increase their physical activity level. Whereas in the past, exercise advice included relatively rigid prescriptions focused on specific amounts, types, and intensities of activity, the recent recommendations and research offer more options. Although there is nothing wrong with the traditional, structured approach to giving physical activity advice, this approach does not work well for all individuals. The lifestyle intervention approach offers more flexibility and encourages patients to develop the behavioral and cognitive skills to incorporate 30 minutes of physical activity into their daily routines.

Controlled intervention studies to evaluate behavioral methods for increasing physical activity in sedentary adults are a new area of investigation, with virtually all controlled trials being conducted since 1990. At the Cooper Institute, we have conducted large-scale, randomized, physical activity intervention trials with sedentary adults.<sup>14,15</sup> The overall objective of these studies has been to modify, implement, and evaluate cog-

nitive and behavioral intervention strategies that have been applied in smoking cessation, dietary intervention, and other behavioral change programs.

The summary from our research and that of others is that these methods are effective, and the results are comparable to the more intensive and costly traditional, structured exercise interventions. A key finding of the research is that individuals who implement cognitive and behavioral strategies such as self-monitoring, goal setting, evaluation of progress, and identification of barriers are the individuals who are substantially more likely than people who do not use these strategies to be meeting the public health physical activity recommendation at 24 months. We find that 25–30% of initially sedentary and unfit adults exposed to the lifestyle intervention will be meeting the public health recommendation for physical activity at the end of the study.

We have incorporated the findings from three controlled behavioral intervention trials into an “off-the-shelf” program that is available commercially. This includes a book for laypeople, *Active Living Every Day*,<sup>16</sup> that is accompanied by an online support course. These materials are available from Human Kinetics, and the company also has developed a program to establish Active Living community centers to disseminate the program. Information on the book and overall program can be obtained from Human Kinetics at [www.activeliving.info](http://www.activeliving.info). The authors of this article receive no per-

sonal royalties from the sale of these products.

### Summary

Physical inactivity and low cardiorespiratory fitness increase the risk of developing type 2 diabetes and are associated with higher rates of cardiovascular disease and mortality in people with type 2 diabetes. Clinicians are encouraged to promote adoption of the consensus public health recommendation for physical activity for their sedentary and unfit patients and to stress that the benefit is improved health—not necessarily weight loss. Recent advances in behavioral intervention approaches can make clinicians more successful in helping their sedentary patients become and stay more physically active.

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