

# Less Sitting, More Physical Activity, or Higher Fitness?

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## Abstract

Epidemiological studies have found that time spent in sedentary behaviors, levels of physical activity, and cardiorespiratory fitness are all associated with mortality rates. They are also related to the risks of obesity, type 2 diabetes mellitus, hypertension, cardiovascular disease, aging-associated frailty, and cancer. The evidence is such that the National Institutes of Health recently launched a new Common Fund initiative aimed at identifying the molecular transducers of adaptation to physical activity in various tissues and organs. It has been estimated that 9.4% of all 57 million deaths in the world in 2008 could be attributed to physical inactivity, which translates into more than 5 million deaths worldwide. Physical inactivity has a deleterious effect that is comparable to smoking and obesity. Importantly, this global estimate relates to levels of physical activity and does not take into account sedentary behavior and cardiorespiratory fitness. Currently, there are national and international guidelines for physical activity level that are highly concordant. The weekly recommendations include 150 minutes of moderate-intensity activity, 75 minutes of vigorous-intensity activity, or some combination of moderate and vigorous activity with 2 days of resistance exercise. However, these guidelines offer no recommendations regarding sedentary time or goals for cardiorespiratory fitness levels. It will be increasingly important for disease prevention, successful aging, and reduction of premature mortality to broaden the focus of the public health message to include not only more physical activity but also less sitting and higher cardiorespiratory fitness. We briefly review the evidence and discuss key issues to be addressed to make this approach a reality.

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Epidemiological studies have found that time spent in sedentary behaviors, level of physical activity, and cardiorespiratory fitness are all associated with mortality rates. Other studies have revealed that they are also related to the risks of obesity, type 2 diabetes mellitus, hypertension, cardiovascular disease, aging-associated frailty, and cancer. These observations are complemented by multiple experimental studies and controlled interventions. The evidence is such that the National Institutes of Health (NIH) recently launched a new Common Fund initiative aimed at identifying the molecular transducers of adaptation to physical activity in various tissues and organs.<sup>1</sup>

It has been estimated that 9.4% of all 57 million deaths in the world in 2008 could be attributed to physical inactivity, which translates into more than 5 million deaths worldwide.<sup>2</sup> Physical inactivity has a deleterious effect that is comparable to smoking and obesity.<sup>2</sup> If only deaths from noncommunicable diseases were considered, the proportion of deaths attributable to physical inactivity is appreciably higher. This is

an issue of great importance because there were 36 million deaths due to noncommunicable diseases (63% of all deaths) in 2008, and this number will increase to 55 million by 2030.<sup>3</sup>

Importantly, these global estimates relate to levels of physical activity, and they do not take into account sedentary behavior and cardiorespiratory fitness. Currently, there are national and international guidelines for physical activity level that are highly concordant.<sup>4,5</sup> The weekly recommendations include 150 minutes of moderate-intensity activity, 75 minutes of vigorous-intensity activity, or some combination of moderate and vigorous activity with 2 days of resistance exercise. However, they offer no recommendations regarding sedentary time or goals for cardiorespiratory fitness levels. We speculate that it will be increasingly important for disease prevention, successful aging, and reduction of premature mortality to broaden the focus of the public health message to include less sitting, more physical activity, and higher cardiorespiratory fitness. We briefly review the

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evidence and discuss key issues to be addressed to make this approach a reality.

### SITTING AND ALL-CAUSE MORTALITY

The independent role of sedentary behavior as a risk factor for poor health and premature mortality has received considerable attention in recent years.<sup>6,7</sup> Sedentary behavior has been defined as any waking behavior characterized by an energy expenditure that is less than or equal to 1.5 times the resting metabolic rate while in a sitting or reclining posture.<sup>8</sup> It has been operationalized in several ways in scientific studies, including the use of television viewing as a marker of sedentary time,<sup>9</sup> time spent at low counts on an accelerometer (ie, <100 counts per minute),<sup>10</sup> or self-reported time spent sitting.<sup>11</sup> Sedentary time has been differentiated from physical inactivity per se in that physical inactivity (or insufficient physical activity) represents the lack of attaining physical activity recommendations (ie, 150 min/wk of moderate-intensity activity or 75 min/wk of vigorous-intensity activity) rather than participating in sedentary behaviors such as sitting or reclining.<sup>12</sup> It is possible that an individual can be considered physically active by meeting the guidelines yet also engage in several hours of sedentary behavior.<sup>13</sup>

The term *sedentary* is derived from the Latin word *sedere*, which literally means “to sit.”<sup>14</sup> The first study that comprehensively examined sitting as an independent risk factor for mortality was based on analyses of mortality rates in the Canada Fitness Survey follow-up study.<sup>15</sup> The results revealed a significant positive dose-response association between daily sitting and mortality from all causes as well as from cardiovascular diseases. The dose-response association was observed after stratification by sex, smoking status, body mass index (BMI) category, and physical activity level. A recent meta-analysis of time spent sitting and all-cause mortality in 6 prospective studies reported a 34% higher risk among adults sitting more than 10 h/d compared with 1 h/d, after adjustment for physical activity.<sup>11</sup> Further, the dose-response association was nonlinear, with hazard ratios (HRs) of 1.00 (95% CI, 0.98-1.03), 1.02 (95% CI, 0.99-1.05), and 1.05 (95% CI, 1.02-1.08) for every 1-hour increase in sitting time in intervals between 0 to 3, 4 to 7, and more than

7 h/d total sitting, respectively, after adjustment for physical activity.<sup>11</sup>

Most studies to date have reported independent effects of sitting by statistically adjusting for level of physical activity and/or stratifying the sample into those who are meeting or not meeting physical activity recommendations. Overall, the results indicate that sitting may be an independent risk factor; however, the results also suggest that the relative risks of sitting are more pronounced in people who are not meeting physical activity guidelines (insufficiently active). The results of a recent meta-analysis revealed that the effect of sedentary time on all-cause mortality was greater among those with low levels of physical activity (HR, 1.46; 95% CI, 1.22-1.75) compared with those with high levels of physical activity (HR, 1.16; 95% CI, 0.84-1.59).<sup>6</sup>

Although there is evidence that greater sedentary time is associated with an increased risk of all-cause mortality, research is needed on the dose-response associations between sedentary behavior and health outcomes and the effects of interventions to reduce sedentary behavior. At the present time, we do not know the threshold of sedentary behavior for health outcomes, and we also do not know the effects of replacing sedentary behavior with other activities such as standing, walking, or moderate to vigorous activity. Further information on both of these issues will be important to inform public health recommendations related to sedentary behavior, and more research is required using novel epidemiological analytical approaches such as compositional analysis and isotemporal substitution analysis, as well as carefully conducted intervention studies.

### PHYSICAL ACTIVITY AND ALL-CAUSE MORTALITY

The role of physical activity in the prevention of chronic disease and premature mortality is well established.<sup>2</sup> More than 50 years of systematic epidemiological and intervention research contributed to the development of the 2008 *Physical Activity Guidelines for Americans*,<sup>4</sup> which call for 150 minutes of moderate activity, 75 minutes of vigorous activity, or some combination of moderate and vigorous activity. Similar guidelines have been promoted by other countries and by the World Health Organization.<sup>5</sup>

The seminal studies of Morris et al<sup>16</sup> on physical activity and coronary heart disease

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