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REFERENCES

1. Physical Activity Guidelines Advisory Committee. *Physical Activity Guidelines Advisory Committee Report 2008*. Washington, DC: US Dept of Health and Human Services; 2008.
2. World Health Organization. *Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks*. Geneva, Switzerland: WHO Press; 2009.
3. World Health Organization. *Global Recommendations on Physical Activity for Health*. Geneva, Switzerland: WHO Press; 2010.
4. Pate RR, O'Neill JR, Lobelo F. The evolving definition of "sedentary." *Exerc Sport Sci Rev*. 2008;36(4):173-178.
5. Brown WJ, Bauman AE, Owen N. Stand up, sit down, keep moving: turning circles in physical activity research? *Br J Sports Med*. 2009;43(2):86-88.
6. Owen N, Bauman A, Brown W. Too much sitting: a novel and important predictor of chronic disease risk? *Br J Sports Med*. 2009;43(2):81-83.
7. Proper KI, Singh AS, van Mechelen W, Chinapaw MJM. Sedentary behaviors and health outcomes among adults: a systematic review of prospective studies. *Am J Prev Med*. 2011;40(2):174-182.
8. Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N. Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab*. 2010;35(6):725-740.
9. Dunstan DW, Barr ELM, Healy GN, et al. Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Circulation*. 2010;121(3):384-391.
10. Warren TY, Barry V, Hooker SP, Sui X, Church TS, Blair SN. Sedentary behaviors increase risk of cardiovascular disease mortality in men. *Med Sci Sports Exerc*. 2010;42(5):879-885.
11. Wijndaele K, Brage S, Besson H, et al. Television viewing time independently predicts all-cause and cardiovascular mortality: the EPIC Norfolk study. *Int J Epidemiol*. 2011;40(1):150-159.
12. Stamatakis E, Hamer M, Dunstan DW. Screen-based entertainment time, all-cause mortality, and cardiovascular events: population-based study with ongoing mortality and hospital events follow-up. *J Am Coll Cardiol*. 2011;57(3):292-299.
13. Patel AV, Bernstein L, Deka A, et al. Leisure time spent sitting in relation to total mortality in a prospective cohort of US adults. *Am J Epidemiol*. 2010;172(4):419-429.
14. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sports Exerc*. 2009;41(5):998-1005.
15. van Uffelen JGZ, Wong J, Chau JY, et al. Occupational sitting and health risks: a systematic review. *Am J Prev Med*. 2010;39(4):379-388.
16. Grøntved A, Hu FB. Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality: a meta-analysis. *JAMA*. 2011;305(23):2448-2455.
17. Inoue M, Iso H, Yamamoto S, et al; Japan Public Health Center-Based Prospective Study Group. Daily total physical activity level and premature death in men and women: results from a large-scale population-based cohort study in Japan (JPHC study). *Ann Epidemiol*. 2008;18(7):522-530.
18. 45 and Up Study Collaborators; Banks E, Redman S, Jorm L, et al. Cohort profile: the 45 and Up Study. *Int J Epidemiol*. 2008;37(5):941-947.
19. Craig CL, Marshall AL, Sjöström M, et al. International Physical Activity Questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35(8):1381-1395.
20. Australian Institute of Health and Welfare. *The Active Australia Survey: A Guide and Manual for Implementation, Analysis and Reporting*. Canberra: AIHW; 2003.
21. Brown WJ, Burton NW, Marshall AL, Miller YD. Reliability and validity of a modified self-administered version of the Active Australia physical activity survey in a sample of mid-age women. *Aust N Z J Public Health*. 2008;32(6):535-541.
22. Timperio A, Salmon J, Rosenberg M, Bull FC. Do logbooks influence recall of physical activity in validation studies? *Med Sci Sports Exerc*. 2004;36(7):1181-1186.
23. Ng S, Korda R, Clements M, et al. Validity of self-reported height and weight and derived body mass index in middle-aged and elderly individuals in Australia. *Aust N Z J Public Health*. 2011;35(6):557-563.
24. Ware JE, Snow KK, Kosinski M, et al. *SF-36 Health Survey: Manual and Interpretation Guide*. Boston, MA: Health Institute, New England Medical Center; 1993.
25. Lee C, Dobson AJ, Brown WJ, et al. Cohort profile: the Australian Longitudinal Study on Women's Health. *Int J Epidemiol*. 2005;34(5):987-991.
26. Cox DR. Regression models and life tables. *J R Stat Soc B*. 1972;34(2):187-220.
27. Rockhill B, Newman B, Weinberg C. Use and misuse of population attributable fractions. *Am J Public Health*. 1998;88(1):15-19.
28. World Health Organization. *Obesity: Preventing and Managing the Global Epidemic: Report of a WHO Consultation*. Geneva, Switzerland: WHO; 2000. WHO Technical Report Series 894.
29. Chau JY, der Ploeg HP, van Uffelen JG, et al. Are workplace interventions to reduce sitting effective? a systematic review. *Prev Med*. 2010;51(5):352-356.
30. Hamilton MT, Hamilton DG, Zderic TW. Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes*. 2007;56(11):2655-2667.
31. Hamilton MT, Healy GN, Dunstan DW, Zderic TW, Owen N. Too little exercise and too much sitting: inactivity physiology and the need for new recommendations on sedentary behavior. *Curr Cardiovasc Risk Rep*. 2008;2(4):292-298. doi: 10.1007/s12170-008-0054-8.
32. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008;40(1):181-188.

INVITED COMMENTARY

New Exercise Prescription

Don't Just Sit There: Stand Up and Move More, More Often

In their article, van der Ploeg and colleagues¹ report important new findings from a large population-based study of Australian adults. They show total sitting time to be associated prospectively with all-cause mortality after accounting for many likely confounding variables, including leisure-time physical activity.

Increasing physical activity in adult populations is central to the prevention of obesity and the major chronic diseases. Traditionally, the focus has been on encouraging individuals to participate in moderate-to-vigorous physical activity ("health-enhancing exercise") during their discretionary time, with a more recent emphasis on physically active transportation.² For example, an indi-

vidual who does 30 minutes of brisk walking on most days of the week will have met the public health guideline on the minimum amount of activity required for health benefits. However, this still leaves some 15½ hours of nonexercise awake time each day during which, for many adults, sitting is the predominant stance. This is a consequence of the plethora of ways in which the physical, economic, and social environments have changed, particularly since the middle of the past century. These changes—in personal transportation, communication, workplace productivity, and domestic entertainment technologies—have been associated not only with decreased physical activity but also with increased time spent sitting.³

The findings from van der Ploeg and colleagues provide a substantial contribution to the rapidly accumulating body of evidence from observational studies identifying sedentary behavior (time spent sitting) as an important risk factor for chronic disease.⁴ The authors conclude that reducing total time spent sitting as a population health risk may be at least as important as increasing participation in physical activity. To put this in perspective, 30 minutes of physical activity is as protective an exposure as 10 hours of sitting is a harmful one.⁴

The observation that prolonged sitting is hazardous to one's health is not new. A relationship between sedentary behavior and deleterious health consequences in workers was noted as early as the 17th century by occupational physician Ramazzini.⁵ In the 1960s, Morris and colleagues⁶ reported that workers in occupations requiring much sitting (London bus drivers and mail sorters) had higher incidences of cardiovascular disease than did workers who were required to stand and ambulate (bus conductors and postal workers). In the preceding decade, Homans⁷ reported clinical cases of venous thrombosis in the legs following prolonged sitting while attending a theater performance and watching television. This led him to recommend that “such matters are important enough to suggest the advisability of making movements of the toes, feet, and lower legs when one is sitting for long periods and of getting up and exercising when opportunity offers.”^{7(p149)}

A possible weakness of the study by van der Ploeg and colleagues and similar cohort studies is that the main exposure variable (sitting time) is based on self-report. Newer objective-measurement capacities made possible by accelerometers—small electronic devices worn on the hip during waking hours—provide further insights. For example, examining 7 days of accelerometer data from a nationally representative sample of 1714 white adults aged 20 to 59 years from the US National Health and Nutrition Examination Survey,³ it is striking that the vast majority of daily nonsleeping time is spent in either sedentary behavior (58%) or light-intensity activity (eg, strolling, washing dishes, and gardening) (39%) and only 3% in health-enhancing physical activity time.

Moreover, because time spent in moderate-to-vigorous physical activity is such a small component of the overall waking day, almost all the variance in sedentary time across the population is related to the extent to which the sedentary time displaces light-intensity activity.³ Indeed, one such study⁸ has reported an almost-perfect inverse correlation (−0.98) of the time spent in light-intensity activity with sedentary time. Therefore, in addition to the benefits of moderate-to-vigorous activity, health gains should accrue through redressing the imbalance between sitting time and light-intensity activity.

Besides the decreased energy metabolism of sitting compared with light-intensity activity,⁹ sitting may also be harmful because of the prolonged absence of muscle contractile activity in the lower limbs. Efforts to reduce sedentary behavior will require attention to workplace regulations, occupational health and safety policy and practice, transportation planning, and innovations in the design of communication technologies, as well as public education campaigns.

With this new study, evidence is sufficiently strong that physicians should be advising patients to reduce daily sitting time. The good news is that increasing light-intensity activity may be a feasible goal for many and offers great health benefits.

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1. van der Ploeg HP, Chey T, Korda RJ, Banks E, Bauman A. Sitting time and all-cause mortality risk in 222 497 Australian adults. *Arch Intern Med.* 2012; 172(6):494-500.
2. World Health Organization. *Global Recommendations on Physical Activity for Health.* Geneva, Switzerland: WHO; 2010.
3. Owen N, Sparling PB, Healy GN, Dunstan DW, Matthews CE. Sedentary behavior: emerging evidence for a new health risk. *Mayo Clin Proc.* 2010;85(12):1138-1141.
4. Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. *Exerc Sport Sci Rev.* 2010;38(3): 105-113.
5. Franco G. Ramazzini and workers' health. *Lancet.* 1999;354(9181):858-861.
6. Morris JN, Kagan A, Pattison DC, Gardner MJ. Incidence and prediction of ischaemic heart-disease in London busmen. *Lancet.* 1966;2(7463):553-559.
7. Homans J. Thrombosis of the deep leg veins due to prolonged sitting. *N Engl J Med.* 1954;250(4):148-149.
8. Healy GN, Matthews CE, Dunstan DW, Winkler EA, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. *Eur Heart J.* 2011;32(5):590-597.
9. Levine JA, Vander Weg MW, Hill JO, Klesges RC. Non-exercise activity thermogenesis: the crouching tiger hidden dragon of societal weight gain. *Arterioscler Thromb Vasc Biol.* 2006;26(4):729-736.