



Are we facing a new paradigm of inactivity physiology?

Elin Ekblom-Bak,^{1,2} Mai-Lis Hellénus,¹
Björn Ekblom²

Evidence for the benefits of regular physical activity for several major health diseases is clear and unanimous. Current public health guidelines are promoting at least 150 minutes per week of moderate to vigorous-intensity leisure-time physical activity.

Recent, observational studies have suggested that prolonged bouts of sitting time and lack of whole-body muscular movement are strongly associated with obesity, abnormal glucose metabolism, diabetes, metabolic syndrome, cardiovascular disease (CVD) risk and cancer, as well as total mortality independent of moderate to vigorous-intensity physical activity.¹⁻⁵ Accordingly, a possible new paradigm of inactivity physiology is suggested, separate from the established exercise physiology, that is, molecular and physiological responses to exercise.⁶ This new way of thinking emphasises the distinction between the health consequences of sedentary behaviour, that is, limiting everyday life non-exercise activity and that of not exercising. Until now, the expression "sedentary behaviour" has misleadingly been used as a synonym for not exercising. Sedentary time should be defined as the muscular inactivity rather than the absence of exercise.

The new proposed paradigm of inactivity physiology is based on four tenets:⁷

- (1) Sitting and limiting non-exercise activity may independently increase the disease risk.
- (2) Sedentary behaviour is a distinct class of behaviour with specific determinants and effects on disease risk, separate from the behaviour of leisure-time exercise.

- (3) The molecular and physiological responses in the human body of too much sitting are not always the same as the responses that follow a bout of additional physical exercise.
- (4) People already insufficiently physically active will increase their risk even further by prolonged sitting time.

The quantitative effects of sitting time were compared with the corresponding inverse effects of physical exercise in a large representative sample of Australian adults.⁸ It was reported that each 1-h increase in sitting time watching television increased the prevalence of the metabolic syndrome in women by 26%, independent of the amount of moderate to vigorous-intensity physical exercise performed. This was approximately the same quantity of decreased risk (28%) of the metabolic syndrome that was induced by 30 minutes of extra physical exercise.

To establish a causal effect between sedentary time and various disease conditions, it is essential to understand the regulatory molecular and physiological mechanisms involved. Although much more research is needed to prove the paradigm of inactivity physiology, some possible underlying mechanisms have already been proposed. Altering of lipoprotein lipase (LPL) expression and activity is one such option.⁹ LPL plays a central role in lipid metabolism. A large amount of research has reported the effects of LPL on the local uptake of plasma triglycerides, alterations in muscle glucose, fatty acid metabolism, high-density lipoprotein cholesterol, metabolic syndrome, atherosclerosis and cardiovascular disease incidence. Recent findings show that the activity of LPL was significantly lower in rats with restrained muscular activity, that is, down to one tenth of the levels of those rats who were allowed to perform non-exercise activity such as standing and ambulating. This resulted in lower triglyceride uptake into skeletal muscle and reduced plasma high-density lipoprotein concentrations in the rats with muscular inactivity. Also interesting was that LPL

activity during non-exercise activity was not significantly different from that of rats exposed to higher levels of exercise activity. This stresses the importance of local muscle contraction *per se*, rather than the intensity of the contraction, for the activity of LPL.

Intervention studies and mechanistic studies are needed to explore the possible detrimental effects of sitting time on various disease conditions. The majority of studies conducted so far are based on self-reported sedentary time, mainly defined as time spent watching television. This subjective method of measurement has often correctly been criticised for its limited capacity to assess sedentary time accurately. Similar independent associations of sedentary time with metabolic risk were recently obtained by the objective measurement of accelerometry.¹⁰ Beneficial effects of breaks in sedentary time were also reported, that is, repetitive bouts of muscular contractions interrupting muscular inactivity, compared with individuals who spent exactly the same time sitting during the day without breaks.¹¹ These effects were independent of the total sedentary time.

In summary, the present amount of research supporting the independent importance of sedentary behaviour is small but consistent. It indicates that we should not only consider the aspect of regular exercise or lack of exercise. We need to consider that we are dealing with two distinct behaviours and their effects: (1) the benefits of regular moderate to vigorous-intensity physical exercise and (2) the risks of too much sitting and limited non-exercise everyday life activity. If found to be true, the clinical importance and implication of this new paradigm is extensive. In the future, the focus in clinical practice and guidelines should not only be to promote and prescribe exercise, but also to encourage people to maintain their intermittent levels of non-exercise daily activities. Climbing stairs rather than using elevators and escalators, 5 minutes of break during sedentary work, or walking to the store rather than taking the car will be as important as exercise. In the demanding and stressful society of the present, to prescribe these low and minimally time-consuming efforts may encourage many people with problems in maintaining a sufficient level of exercise. Encouragingly, research has shown that simple forms of prescribing individualised physical activity in clinical practice has had a beneficial impact on exercise level as well as sedentary time.¹²

¹ Department of Medicine, Clinical Epidemiology Unit, Karolinska Institutet, Karolinska University Hospital, Stockholm, Sweden; ² Åstrand Laboratory of Work Physiology, The Swedish School of Sport and Health Sciences, Stockholm, Sweden

Correspondence to: Elin Ekblom-Bak, Åstrand Laboratory of Work Physiology, Swedish School of Sport and Health Sciences, Box 5626, 114 86 Stockholm, Sweden; eline@gjh.se

Competing interests: None.

Accepted 4 November 2009

Br J Sports Med xxxx;xx:xxx–xxx
doi:10.1136/bjism.2009.067702

REFERENCES

1. **Jakes RW**, Day NE, Khaw KT, *et al.* Television viewing and low participation in vigorous recreation are independently associated with obesity and markers of cardiovascular disease risk: EPIC-Norfolk population-based study. *Eur J Clin Nutr* 2003;**57**:1089–96.
2. **Hu FB**, Leitzmann MF, Stampfer MJ, *et al.* Physical activity and television watching in relation to risk for type 2 diabetes mellitus in men. *Arch Intern Med* 2001;**161**:1542–8.
3. **Bertrais S**, Beyeme-Ondoua JP, Czernichow S, *et al.* Sedentary behaviors, physical activity, and metabolic syndrome in middle-aged French subjects. *Obes Res* 2005;**13**:936–44.
4. **Dunstan DW**, Salmon J, Owen N, *et al.*; AusDiab Steering Committee. Physical activity and television viewing in relation to risk of undiagnosed abnormal glucose metabolism in adults. *Diabetes Care* 2004;**27**:2603–9.
5. **Katzmarzyk PT**, Church TS, Craig CL, *et al.* Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sports Exerc* 2009;**41**:998–1005.
6. **Hamilton MT**, Hamilton DG, Zderic TW. Exercise physiology versus inactivity physiology: an essential concept for understanding lipoprotein lipase regulation. *Exerc Sport Sci Rev* 2004;**32**:161–6.
7. **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**:2655–67.
8. **Dunstan DW**, Salmon J, Owen N, *et al.*; AusDiab Steering Committee. Associations of TV viewing and physical activity with the metabolic syndrome in Australian adults. *Diabetologia* 2005;**48**:2254–61.
9. **Bey L**, Hamilton MT. Suppression of skeletal muscle lipoprotein lipase activity during physical inactivity: a molecular reason to maintain daily low-intensity activity. *J Physiol (Lond)* 2003;**551**:673–82.
10. **Healy GN**, Wijndaele K, Dunstan DW, *et al.* Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Diabetes Care* 2008;**31**:369–71.
11. **Healy GN**, Dunstan DW, Salmon J, *et al.* Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care* 2008;**31**:661–6.
12. **Kallings LV**, Sierra Johnson J, Fisher RM, *et al.* Beneficial effects of individualised physical activity on prescription on body composition and cardiometabolic risk factors: results from a randomised controlled trial. *Eur J Cardiovasc Prev Rehabil* 2009;**16**:80–4.