Res Exerc Epidemiol 2013; 15(1): 1-6

【Review Article】

Reducing Sedentary Time or Increasing Moderate and Vigorous Intensity Physical Activity in Youth? Associations with Health Outcomes

Ulf Ekelund[1,2)]

1) Department of Sport Medicine, Norwegian School of Sport Sciences, Oslo, Norway
2) Medical Research Council Epidemiology Unit, University of Cambridge, Cambridge, UK

ABSTRACT Current recommendations for physical activity in young people state that those between 5 and 18 years of age should accumulate at least 60 minutes of moderate and vigorous intensity physical activity per day. Emerging evidence suggest that the majority of young people do not achieve the recommended levels of activity which may influence on their health. On the opposite end of the energy expenditure spectrum, sedentary time has been recognised as a potential risk factor for chronic disease in adults.

Recent systematic reviews have suggested there is little evidence for a prospective association between baseline time spent sedentary and later health outcomes. There is a paucity of data examining the prospective associations between objectively measures physical activity and health outcomes. However, the cross-sectional evidence linking time in moderate and vigorous intensity physical activity with cardio-metabolic health outcomes is consistent with potentially greater magnitude of association for more vigorous intensity activity. Further, time spent sedentary appears unrelated to these outcomes following appropriate adjustments for time in moderate and vigorous intensity physical activity. The appropriate amount of time in moderate and vigorous intensity physical activity needed to prevent cardiovascular dysfunction in young people needs to be determined and the potential benefits of more vigorous intensity physical activity established. Additional large scale, well-designed prospective studies and randomised controlled trials are warranted to address these uncertainties.

Introduction

Most public health authorities [1-6)] agree that young people, broadly defined as 5 to 18 years of age, should accumulate at least 60 min of moderate-and-vigorous-intensity physical activity (MVPA) on at least 5 days per week. In addition, the benefits of vigorous-intensity activity (VPA) and strength conditioning exercises are acknowledged. And some of these authorities also specifically provide recommendations for limiting the amount of time spent sedentary[5)]. Although the underlying evidence for these recommendations maybe weak, they provide a framework when evaluating population levels of sedentary time and physical activity (PA) in youth.

Recent objective data from the National Health and Nutrition Examination Survey (NHANES) in the US showed that those aged 12 to 19 years spent between 50% and 60% of day time sedentary, an amount of time comparable with those aged > 60 years[7)]. Data from the Helena study comprising 9 European countries (n = 2,200) have suggested that 71% of the measured time was spent sedentary in 12 to 18 year old boys and girls[8)]. Further, time spent sedentary increases by approximately 1.5 hours between 12 and 16 years of age in a large sample of UK children[9)]. Taken together, these data obtained by objective measures of sedentary time suggest that; 1) contemporary young people spend a significant amount of time sedentary; 2) sedentary time appears to increase by age throughout adolescence and; 3) the sex differences both in total sedentary time and the rate of increase in sedentary time are small.

Global estimates of young peoples' self-reported time spent in PA suggest that 80% of 13-15 year old boys and girls do not achieve the recommended 60

Address for correspondence: Ulf Ekelund; Department of Sport Medicine, Norwegian School of Sport Science, PO Box 4014, Ullevål Stadion, 0806 Oslo, Norway; ulf.ekelund@nih.no

minutes of MVPA per day[10]. In opposite to the fairly consistent data on time spent sedentary, data on objectively measured time spent in MVPA vary considerably between studies due to the different definitions of moderate intensity activity. Summary data on the percentages of youth accumulating > 60 minutes of MVPA per day from studies including more than 1,000 participants in which activity was measured by accelerometry varied between 0% and 100%[11]. To overcome this discrepancy attempts have been made to pool and reanalyse accelerometry data [12]. Unpublished data in more than 32,000 youth from the International Accelerometer database (ICAD) suggest that approximately 37% of children and 27% of adolescents accumulated at least 60 minutes of MVPA per day (Ekelund, unpublished observations). In summary, the majority of youth do not accumulate the recommended levels of physical activity every day; boys are consistently more active than girls when activity is defined as time spent in MVPA; and, activity levels decline by age. Given the large amount of time spent sedentary and the apparently low prevalence of youth being physically active according to PA recommendations for health it is pertinent to ask whether sedentary time and PA are associated with health outcomes in youth and whether these associations are independent of each other and other confounding factors.

Is Sedentary Time Associated with Health Outcomes in Youth?

Sedentary behavior has been defined as activities characterized by sitting or reclining position and requiring an energy expenditure < 1.5 METs (Metabolic Equivalent Tasks; multiples of the basal metabolic rate). This behavior has gained tremendous interest from researchers during the last years due to its potentially hazardous health effects. Longer hours of total sitting time has been linked with all-cause mortality[13] and recent meta-analyses have suggested that TV viewing is associated with increased risk of type 2 diabetes, cardiovascular disease and all-cause mortality in adults[14-16].

Tremblay et al.[17] reviewed the literature on the associations between sedentary behavior and health outcomes in children including 232 studies with a total of more than 983,000 participants. The authors concluded there is a large body of evidence suggests that decreasing any type of sedentary behavior is associated with lower health risks, particularly lower obesity risk, in children aged 5 to 17 years. In contrast, another systematic review examining the prospective associations between sedentary behavior and health outcomes in youth concluded there is insufficient evidence for a longitudinal positive relationship between sedentary behaviors and body mass index (BMI), more specific indicators of fat mass and other health indicators such as blood pressure, blood lipids and bone health[18]. This conclusion was partly confirmed in another systematic review examining the prospective associations between sedentary behavior and weight gain during the last two years which suggested weak evidence for a longitudinal association between self-reported and objectively measured sedentary time and weight gain[19]. The authors also highlighted the failure to appropriately adjust the longitudinal results for baseline measures of the outcome[19]. In longitudinal studies trying to decide temporal sequence and the direction of causality, one of the key components are that the cause precedes the effect. When baseline measures are not accounted for, causality cannot be determined, suggesting that in studies that did not adjust their results for the baseline measure of the outcome (e.g. BMI) there are not clear evidences that sedentary behavior leads to weight gain. The contra- dictory conclusions from these systematic reviews are likely explained by different inclusion criteria (i.e. all study designs vs. prospective cohort and intervention studies) and a more rigorous assessment of study quality.

The vast majority of studies used self-reported TV-viewing as an indicator of sedentary behavior and should be interpreted cautiously. First, self-reported TV-viewing is prone to recall bias. Second, TV-viewing may be a proxy of a generally unhealthy lifestyle, associations may therefore be explained by residual confounding. Finally, total time spent sedentary is the reciprocal of overall physical activity energy expenditure (PAEE). Studies that have claimed the association between sedentary time and any health outcome is independent of PA have adjusted their

analyses for a sub-component of PA, e.g. time spent in MVPA or self-reported leisure time activity. It could therefore be hypothesized that the observed associations between sedentary time and health outcomes would be similar but in opposite direction (i.e. inverse) when employing a precise measure of overall PA.

Few studies have examined the prospective association between objectively measured sedentary time and health outcomes in young people. These studies are less prone to biases compared with self-report, and reduce the potential for differential measurement errors. One of these studies did observe a positive association between sedentary time and increases in BMI above the 50th percentile on girls between ages 9 years and 15 years[20] suggesting the magnitude of association is more pronounced in those whom are categorized as overweight or obese at the initial assessment. In contrast, no association was reported between sedentary behavior and increased BMI z-score from ages 7 to 9 years in UK children[21]. Others have suggested that the association between sedentary time and gain in adiposity may be reverse. That is, baseline sedentary time is unrelated to gain in adiposity whereas greater adiposity level at baseline predicts higher amounts of sedentary time at follow-up as observed in both children[22] and adults[23]. However, even if both the latter studies assessed sedentary time objectively differences in measurements precision between the exposure and outcome should be considered when interpreting these results. When the more imprecise variable is used as the outcome, the magnitude of effect is estimated accurately, but with error. When the more imprecise variable is used as the exposure, the measure of effect is attenuated. Because PA and sedentary time are measured much less precisely than is body weight, it is not surprising that baseline body weight predicts follow-up PA, whereas, because of measurement error, the reverse may not be observed.

Is Physical Activity Associated with Health Outcomes?

Total amount of PA and time spent in MVPA are both associated with cardio-metabolic risk factors in well-designed, large-scale observational studies in children. However, most of the evidence has emerged from cross-sectional association studies. For example, Andersen et al.[24] showed a graded inverse relationship between the total volume of PA measured by accelerometry and clustered metabolic risk. The highest risk was observed in the three lowest quintiles of PA. Interestingly, the results from this study also suggested that the current recommendation of 60 minutes of MVPA may be too low for reducing cardiovascular risk factors in youth. However, due to the cross-sectional nature of the study and the marked variability in intensity thresholds used to define MVPA, additional studies are required to confirm or refute whether the current recommendations of 60 minutes of MVPA per day should be refined. Additional research has suggested that total PA assessed by accelerometry appears to be inversely associated with cardiovascular metabolic risk factors independent of both body fatness and aerobic fitness[25]. This observation is important for public health as it suggests that increasing overall activity levels in populations of young people may have important health implications regardless of whether there are any changes in aerobic fitness or body fatness.

Another important question for preventive purposes and public health policy relates to whether the magnitude of associations differ between different intensity levels of PA (e.g. light, moderate and vigorous intensity) and cardio-metabolic health outcomes in young people. Some recent studies have reported a greater magnitude of association between more vigorous intensity of PA and adiposity indicators in young people. Steele et al.[26] examined the associations between various sub-components of objectively measured sedentary time, and PA in a large sample (n = 1,862) 9-10 year old British children and observed that the strongest and most consistent associations between activity and adiposity indicators such as BMI, waist circumference and fat mass was observed for VPA. Another study examined these associations in 4 year old British pre-school children (n = 398) in which PA was assessed by accelerometry and body composition by DXA measurements[27]. Time spent in vigorous intensity activity was the only variable consistently associated with all indicators of adiposity

(BMI, waist circumference, fat mass, and trunk fat mass) after controlling for a number of confounding factors, including time spent sedentary. This observation is indirectly supported by data suggesting that objectively measured sedentary time is unrelated to adiposity in pre-schoolers[28]. Taken together, the results from these studies indicate that efforts to challenge paediatric obesity may benefit from prioritizing vigorous intensity physical activity rather than focusing on sedentary time. If the results from the study by Collins et al.[27] are replicated the current physical activity recommendations for pre-schoolers [5,6] which specify the amount (> 180 min of activity per day) without considering the intensity of physical activity may need to be reconsidered.

The focus on MVPA rather than sedentary time in relation to health indicators in youth was further acknowledged in a large pooled analysis comprising more than 20,000 young people between 4 and 18 years of age[22]. The authors examined the independent associations between sedentary time and MVPA with cardio-metabolic risk factors including waist circumference, blood pressure, triglycerides, HDL-Cholesterol and insulin sensitivity. Time in MVPA was associated with all metabolic outcomes independent of sex, age, monitor wear time, time spent sedentary and waist circumference (when this variable was not the outcome). Time spent sedentary was not associated with any of the metabolic outcomes after adjusting for time in MVPA. The differences in outcomes between higher and lower MVPA were greater with lower sedentary time. Mean differences in waist circumference between the bottom and top tertiles of MVPA were 5.6 cm (95%CI, 4.8-6.4 cm) for high sedentary time and 3.6 cm (95%CI, 2.8-4.3 cm) for low sedentary time. Mean differences in systolic blood pressure for high and low sedentary time were 0.7 mmHg (95%CI, −0.07 to 1.6) and 2.5 mmHg (95% CI, 1.7-3.3), and for high-density lipoprotein cholesterol, differences were −2.6 mg/dL (95%CI, −1.4 to −3.9) and −4.5 mg/dL (95%CI, −3.3 to −5.6), respectively. These differences between tertiles for MVPA are substantial and similar to what have been observed following an extensive lifestyle intervention in adults with type 2 diabetes[29]. It therefore appears appropriate to encourage higher amounts of physical activity of at least moderate intensity in youth and downplay the importance of reducing sedentary time.

Perspectives and Future Directions

The use of accelerometry for assessing time spent sedentary and at various intensity levels of PA has increased our knowledge of population levels of sedentary time and activity. Further, consistent associations with health outcomes have been established. However, there is still a paucity of data examining the prospective associations between sedentary time, light, moderate, and vigorous intensity physical activity with cardio-metabolic and other health outcomes in youth. The appropriate amount of time in MVPA needed to prevent cardiovascular dysfunction in young people needs to be determined and the potential benefits of more vigorous intensity PA established.

References

1) World Health Organization. Global Recommendations on Physical Activity for Health. WHO Press, Geneva, Switzerland, 2010.
2) Centers for Disease Control and Prevention. Physical Activity for Everyone. http://www.cdc.gov/physicalactivity/everyone/guidelines/children.html.
3) Australian Government Department of Health and Ageing. Physical activity recommendations for 5-12 year olds. http://www.health.gov.au/internet/main/publishing.nsf/Content/health-pubhlth-strateg-physact-guidelines.
4) Australian Government Department of Health and Ageing. Physical activity recommendations for 12-18 year olds. http://www.health.gov.au/internet/main/publishing.nsf/Content/health-pubhlth-strateg-physact-guidelines.
5) Canadian Society for Exercise Physiology. Canadian physical activity guidelines information sheet. http://www.csep.ca/english/view.asp?x=804.
6) Department of Health. UK physical activity guidelines.

http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_127931

7) Matthews CE, Chen KY, Freedson PS, Buchowski MS, Beech BM, Pate RR, Troiano RP. Amount of time spent in sedentary behaviors in the United States, 2003-2004. Am J Epidemiol. 2008; 167: 875-81.

8) Ruiz JR, Ortega FB, Martínez-Gómez D, Labayen I, Moreno LA, De Bourdeaudhuij I, Manios Y, Gonzalez-Gross M, Mauro B, Molnar D, Widhalm K, Marcos A, Beghin L, Castillo MJ, Sjöström M; HELENA Study Group. Objectively measured physical activity and sedentary time in European adolescents: the HELENA study. Am J Epidemiol. 2011; 174: 173-84.

9) Mitchell JA, Pate RR, Dowda M, Mattocks C, Riddoch C, Ness AR, Blair SN. A prospective study of sedentary behavior in a large cohort of youth. Med Sci Sports Exerc. 2012; 44: 1081-7.

10) Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U; Lancet Physical Activity Series Working Group. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet. 2012; 380: 247-57.

11) Ekelund U, Tomkinson G, Armstrong N. What proportion of youth are physically active? Measurement issues, levels and recent time trends. Br J Sports Med. 2011; 45: 859-65.

12) Sherar LB, Griew P, Esliger DW, Cooper AR, Ekelund U, Judge K, Riddoch C. International Children's Accelerometry Database (ICAD): Design and methods. BMC Public Health 2011; 11: 485.

13) 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: 494-500.

14) Grøntved A, Hu FB. Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality: a meta-analysis. JAMA. 2011; 305: 2448-55.

15) Wilmot EG, Edwardson CL, Achana FA, Davies MJ, Gorely T, Gray LJ, Khunti K, Yates T, Biddle SJ. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. Diabetologia. 2012; 55: 2895-905.

16) Ford ES, Caspersen CJ. Sedentary behaviour and cardiovascular disease: a review of prospective studies. Int J Epidemiol. 2012; 41: 1338-53.

17) Tremblay MS, LeBlanc AG, Kho ME, Saunders TJ, Larouche R, Colley RC, Goldfield G, Connor Gorber S. Systematic review of sedentary behaveiour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act. 2011; 8: 98.

18) Chinapaw MJ, Proper KI, Brug J, van Mechelen W, Singh AS. Relationship between young peoples' sedentary behaviour and biomedical health indicators: a systematic review of prospective studies. Obes Rev. 2011; 12: e621-32.

19) Kolle E, Ekelund U. Is sitting time a strong predictor of weight gain? Obesity Reports. in press.

20) Mitchell JA, Pate RR, Beets MW, Nader PR. Time spent in sedentary behavior and changes in childhood BMI: a longitudinal study from ages 9 to 15 years. Int J Obes (Lond). 2013; 37: 54-60.

21) Basterfield L, Pearce MS, Adamson AJ, et al. Physical activity, sedentary behavior, and adiposity in English children. Am J Prev Med. 2012; 42: 445-51.

22) Ekelund U, Luan J, Sherar LB, Esliger DW, Griew P, Cooper A. Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. JAMA. 2012; 307: 704-12.

23) Ekelund U, Brage S, Besson H, Sharp S, Wareham NJ. Sedentary time and weight gain in healthy adults; reverse or bidirectional causality? Am J Clin Nutr. 2008; 88: 612-17.

24) Andersen LB, Harro M, Sardinha LB, Froberg K, Ekelund U, Brage S, Anderssen SA. Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). Lancet. 2006; 368: 299-304.

25) Ekelund U, Anderssen SA, Froberg K, Sardinha LB, Andersen LB, Brage S. Independent associations between physical activity and aerobic fitness with metabolic risk factors in children: The European Youth Heart Study. Diabetologia.

2007; 50: 1832-40.

26) Steele R, van Sluijs EMF, Cassidy A, Griffin SJ, Ekelund U. Targeting sedentary time or moderate- and vigorous intensity activity: inde pendent relations with adiposity in a population-based sample of 10-y-old British children. Am J Clin Nutr. 2009; 90: 1185-92.

27) Collins PJ, Brage S, Ridgway CL, Harvey NC, Godfrey KM, Inskip HM, Cooper C, Wareham NJ, Ekelund U. Physical activity intensity, sedentary time and body composition in preschoolers. Am J Clin Nutr. 2013. in press.

28) Byun W, Liu J, Pate RR. Association between objectively measured sedentary behavior and body mass index in preschool children. Int J Obes (Lond). 2013 Jan 15. doi: 10.1038/ijo. 2012.222. [Epub ahead of print]

29) Balducci S, Zanuso S, Nicolucci A, De Feo P, Cavallo S, Cardelli P, Fallucca S, Alessi E, Fallucca F, Pugliese G; Italian Diabetes Exercise Study (IDES) Investigators. Effect of an intensive exercise intervention strategy on modifiable cardiovascular risk factors in subjects with type 2 diabetes mellitus: a randomized controlled trial: the Italian Diabetes and Exercise Study (IDES). Arch Intern Med. 2010; 170: 1794-803.