Curr Obes Rep (2013) 2:42–49
DOI 10.1007/s13679-013-0054-y

ETIOLOGY OF OBESITY (JA MARTINEZ, SECTION EDITOR)

Obesity and Sedentarism: Reviewing the Current Situation Within the WHO European Region

Lideke Middelbeek · João Breda

Published online: 22 February 2013

Abstract Overweight and obesity are major health hazards in the WHO European Region. Both diet patterns and physical activity levels have been widely recognized as the main contributors to the development of overweight/obesity. Over the past few years evidence has been piling up that sedentary behavior, defined as a distinct behavior from physical activity, is also positively associated to overweight/obesity. This review article finds that despite the inconsistent findings on the health impact of sedentary behavior and overweight/obesity, the current trend towards spending more time in sedentary behaviors and the studies that show a positive association between obesity and sedentary behavior make a strong argument for integrating sedentary behavior guidelines in future policy plans, recommendations and actions

Keywords Obesity · Sedentary behavior · Sedentarism · Health impacts · WHO · European region

Introduction

Obesity is one of the greatest public health challenges of the twenty-first century. Its prevalence has tripled in many countries of the WHO European Region since the 1980s, and the numbers of those affected continue to rise, particularly among children [1-4]. In addition to causing various physical disabilities and psychological problems, excess weight drastically increases a person's risk of developing a number of noncommunicable diseases (NCDs), including cardiovascular disease, cancer and diabetes [1-4]. Excessive dietary energy intake and physical inactivity are the most immediate contributors to overweight/obesity. In current obesity discussions sedentary behavior gets a more prominent place [1–4]. The sedentary nature of today's society makes many people spend a substantial amount of time per day on sedentary behaviors. In recent years there has been a rapid growth of evidence generation and gathering concerning the health impact of sedentary behavior and in particular on the relationship between obesity/overweight and sedentary behavior [5••, 6].

Widespread attention at policy level is given to the topic of obesity and its main contributors, partly due to some high level policy pushes of international, regional and national authorities over the over the last decade [1, 2, 4, 7, 8]. Despite the growing confirmatory evidence on the negative health impacts of sedentary behavior, the topic remains under-addressed in public health strategies, plans and guidelines [5••, 9]. Clear global recommendations to promote physical activity have been defined: adults should accumulate at least 30 minutes per day and children and adolescents at least 60 minutes per day of physical activity [10], but guidance on reducing sedentary behavior has not been integrated.

The first objective of this paper is to evaluate the literature on sedentary behavior and obesity published over the past year. After a presentation of what sedentary behavior is, how you measure it and what the current prevalence of sedentary behavior is in the WHO European Region, this article will secondly explore the relationship between sedentary behavior and obesity, including a short overview of the correlates/moderators of sedentary behavior. Thirdly, the article also outlines how sedentary behavior is addressed in intervention and policy programs.

In the past few years there has been a rapid growth of scientific evidence concerning the adverse health impact of sedentary behavior. In their efforts to monitor the levels and impacts of sedentary behavior researchers have been challenged with the paradigm of defining sedentary behavior.

J. Breda (✉)
World Health Organization Regional Office for Europe,
Division of Noncommunicable Diseases
and Health Promotion, Scherfigsvej 8,
2100 Copenhagen, Denmark
e-mail: jbr@euro.who.int

L. Middelbeek
Independent Scientific Writer, Physical Activity and Sedentay
Behavior, Copenhagen, Denmark

However, patterns of sedentary behavior can be identified in a wider range of settings, including school, transport, household, and leisure time. Sitting is the most prevalent sedentary behavior. Typical examples of sedentary behavior include screen time, motorized transport, and sitting to read, talk, do homework or listen to music [5••, 18•].

Measurement of low energy tasks and specific sedentary behaviors can be done either through objective measurement methods, such as accelerometers and inclinometers, or with subjective instruments like self-report or parental report questionnaires or time-use diaries [5••, 18•, 19]. Challenges are experienced in collecting data on patterns and levels of sedentary behavior, mostly due to lack of examined validity and reliability of the instruments and different definitions and cut-offs used for defining sedentary behavior [5••, 18•]). In sedentary behavior research data on the type and amount of sedentary behavior is examined for different age groups and expressed either in terms of prevalence or estimates of time spent in specific sedentary behaviors [5••]. So far, little is known about the patterns of sedentary behavior in different countries, mainly because it has only recently been identified as a public health issue [5••].

Recent data from a cross-national school-based survey from the World Health Organization including 35 European countries showed that 56 % of the 11 year old and 63 % of the 15 year old watch television for two or more hours on weekdays. Gender differences and differences associated with family affluence tended to be modest. The highest prevalence was observed in Slovakia and lowest in Switzerland [20]. Another school based survey conducted in seven European countries found that screen activities were high in all countries with children spending on average more than 2 hours/day in TV and computer activities [21]. Sedentary behavior tends to increase from early to late adolescence and boys are more sedentary than girls [22]. A Scottish study examined sedentary behavior among adolescence and revealed that sedentary activities occupied 228 min per weekday and 396 min per weekend day for boys, and 244 min per weekday and 400 min per weekend day for girls, with TV occupying one-third to one-half of this time [23]. Comparable levels of sedentary behavior were found for Hungarian youth. For sitting significantly lower levels were detected for younger students (13-14) compared to older students (17-18) [24].

When entering into adulthood individuals tend to engage in even more sedentary time [22, 25]. Euro barometer data (2005) gives us insight on average sitting time in European Member States. According to this study an average European Union citizen spends on average just over 5 hours sitting on a normal day, it varies from just over 3 hours in Portugal (198.4 minutes) to more than 8 hours in the Netherlands [26]. Hallal et al. assessed and compared time spent sitting in 66 countries of both high and low income. They found that overall the proportion of adults spending 4 or more hours per day sitting is 41.5 %. A big variation in this percentage has been found between WHO regions, with a percentage of 64.1 for Europe (Fig. 1) [18•]. As illustrated by Fig. 1 for almost all WHO regions the frequencies of sedentary behavior exceed the levels of inactivity. A study by Bauman and colleagues collected sitting time data from 20 countries and found that sitting time varied widely across countries, with a median reported sitting time of 300 minutes per day. Longer sitting times were found for middle-aged adults (40-65 years old) than for young adults (18-39 years old) [27]. A National study undertaken in The Netherlands shows that on average the Dutch working population reported sitting for 7 hours each day, one third of which was at work [28].

Methods

Review of the peer-reviewed literature to identify papers published between 2009 and 2012 looking at obesity and Sedentarism. An extensive literature search was performed to collect studies for inclusion in this paper to increase the likelihood that all important publications were identified. For this review article a literature search was performed using the WHO literature search engine (GIF), a digital database accessible for WHO staff that includes relevant databases such as MEDLINE and PUBMED. The following keywords (or combinations of) were used: Sedentary Behavior/Time, Sitting Behavior/Time, Obesity/Overweight, and Health Impacts. Additional articles were identified by a Google search and by expert consultation.

Defining Sedentary Behavior

Over the years many have interpreted sedentary behavior simply as a lack of physical activity or not meeting the recommended levels of physical activity. However most of the current sedentary behavior research efforts reject this position and prefers to refer to this behavior as a pattern where sitting or lying is the dominant mode of posture and energy, usually with a metabolic energy expenditure of 1.5 MET or less [6, 11, 12]. In contrast for moderate to vigorous physical activities (MVPAs) an energy expenditure of 3-8 METs is required. Numerous studies suggest that engaging in high amounts of sedentary behavior can result in increased risk of morbidity and mortality regardless of levels of MVPA [13, 14]. Furthermore there is often little association between sedentary time and levels of MVPA and individuals can daily have high levels of MVPA and sedentary time [15, 16]. Initial epidemiological studies in the field of sedentary behavior focused on the work setting to monitor the health impacts of sedentary behavior [17].

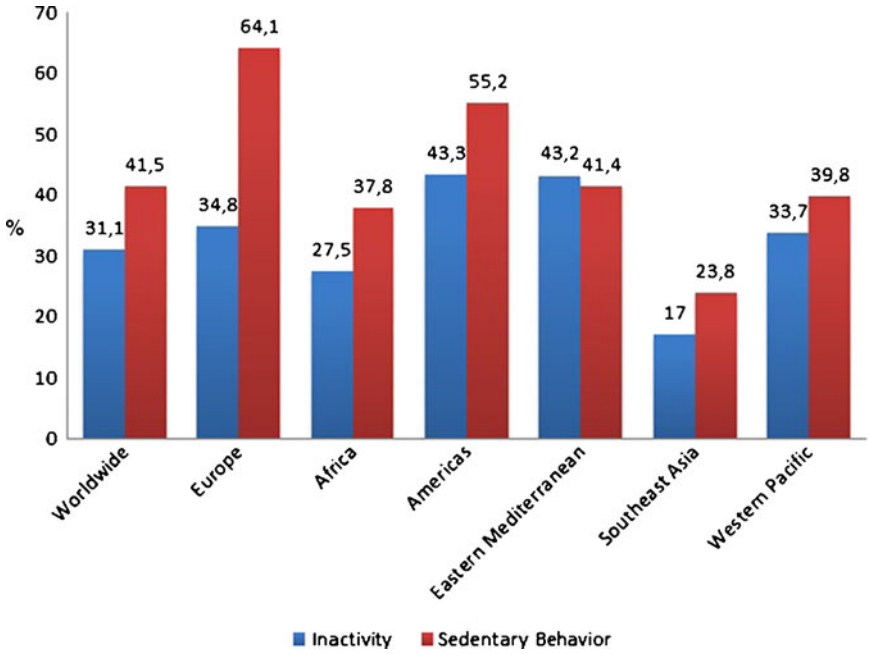

Fig. 1 Comparison between physical inactivity and sedentary behavior patterns of adults by WHO region. Inactivity is defined as not meeting any of the criteria: 30 minutes of MVPA on at least 5 days per week; 20 min of vigorous intensity physical activity on at least 3 days every week; or an equivalent combination achieving 600 MET minutes per week. Sedentary behavior is defined as spending 4 or more hours per day sitting [18•]

Results

Sedentary Behavior and Overweigh/Obesity

Sedentary behavior is furthermore adversely associated with clustering of and individual cardiovascular risk biomarkers such as leptin and cholesterol [5••, 29, 30•, 31•]. The majority of studies however focus on the relationship between obesity/ overweight and sedentary behavior [5••].

Evidence for Youth

A report done by the Sedentary Behavior and Obesity Expert group for the British Department of Health thoroughly reviewed the evidence on the association between sedentary behavior and overweight/obesity [5••]. The report describes two prospective studies that report an increasing likelihood of adult overweight with greater TV viewing in childhood and youth [32, 33]. The authors also explored two reviews which both found a small but significant relationship between body fat and TV viewing [34, 35]. The report concludes based on the available literature that the association does not vary by gender and age, that TV viewing is a predictor for overweight as a young adult and that a greater risk of obesity is expected in groups with higher levels of sedentary behavior. Nevertheless, the review didn't find a clear relation with computer use and playing video games, but for this kind of behavior fewer studies are available [5••].

Various other studies show that time spent in screen-based behaviors contributes to increased BMI [22, 36, 37]. For example, Mitchell et al. found that the odds of obesity increased per sedentary hour among 12 year olds, but this association was not independent of MVPA [22].

There are however also studies that show a less clear or no relationship between gaining weight and sedentary behavior. Barnett et al. examined a cohort of 744, 12-13 year olds and found that the majority of this group has a pattern of 25-30 hours of screen time per week. When linking this to increased body fat, the results do not suggest a clear relation between increase percent body fat if screen use increases over time [38•].

Correlates of Sedentary Behavior for Youth

In order to understand and change a certain behavior key factors that are associated with the behavior need to be identified. Cillero et al. reviewed 44 studies on correlates of different sedentary behaviors published between 1980-2009. They found that older children and children from lower socio-demographic group watched more television. Also, higher levels of parental TV viewing were also associated with higher levels of TV viewing among children. No clear gender differences in TV viewing patterns were identified. For computer use they found that higher levels were linked to boys and older children, but no gender association was found for overall screen time. For general media-use higher levels were found among lower socio-demographic groups and older children [39]. Another review found that body weight, snacking, parent viewing patterns, having a TV in the bedroom and day of the week were all positively associated with TV viewing time [40]. Based on these two

reviews and the inclusions of a few other studies/reviews the authors of the Department for Health report concluded that the potential modifiable correlates of youth screen-viewing are likely to differ by participant age and that for young children, family TV viewing is likely to be associated with child TV viewing; for adolescent BMI is likely to be related to higher levels of screen viewing; and that generally for young people, snacking, body weight, parental TV viewing and having a TV in the bedroom are potential modifiable correlates of screen-viewing. They also found that for young children and adolescents, age, gender and SES are likely to be potential moderators of screen-viewing. For adolescent ethnicity and parental education were also identified as possible moderators. Moderators for young people in general are SES, living in a single parent household, ethnicity and age. Prospective and cross sectional studies have found that TV viewing in childhood and adolescence is associated with greater energy intake and poorer diet [5••]. Various studies examined the relation between sleep duration and overweight in youth and found that short sleep duration was associated with increased TV viewing and BMI [41–43].

Evidence for Adults

The Department of Health review found that the relationship between the gain of bodyweight or development of obesity and sedentary behavior is less clear. Three of the six studies they reviewed showed a positive association, however the effect size was small [5••, 32, 44–48].

Proper and colleagues undertook a systematic review on the health outcomes of sedentary behavior and concluded based on the inconsistent outcomes of five studies that there is so far insufficient evidence for a longitudinal relationship between sedentary behavior and body weight/BMI gain. Based on the inclusion of four prospective studies they came to a similar conclusion for the relation between sedentary behavior and the risk for overweight/obesity [31•]. Conclusions from a review by Van Uffelen et al. about occupational sitting were in line with these findings [49]. These ambiguous findings may be explained by difference in settings, methodologies, and cut-offs used in the studies.

Despite these inconsistencies there are a substantial amount of studies that were able to reveal a positive relationship between sedentary behavior and the risk of overweight/obesity [48, 50–52]. For example Ding et al. undertook a 4 year follow up study including habitual active transport and TV-viewing and found that on average participants gained 1.6 kg over four years. TV viewing time at baseline was positively associated with weight gain at follow-up. Each additional hour of TV viewing was associated with 0.24–0.27 kg of extra weight gain [52].

Correlates of Sedentary Behavior in Adults

In their review the Department of Health report found that there is evidence that for adults sedentary behavior is associated with gender, age, socioeconomic conditions, occupation, some characteristics of the physical environment and weight status. Older adults are likely to spend more time sedentary than middle-aged adults. However for none of these factors a consistent correlation has been found. According to this review positive association has been found between TV viewing and an increased energy intake and consumption of energy-dense snacks, soft drinks, and fast food [5••]. In contrast Rhodes et al. found that total caloric intake and sedentary behavior had limited association [53]. The review by Rhodes and colleagues also demonstrated that those who watch a lot of TV tend to be less educated, older, unemployed or work less hours, and have higher BMI than those who watch less TV. The effect appears to be relatively independent of gender. They also reported that general sitting behavior was not associated with education, ethnicity, or gender. An association between higher TV viewing and lower leisure-time physical activity was present in most of the studies reviewed, but this association was not found for general sitting or computer use. They conclude that considerable evidence has been accumulated on the sociodemographic and behavioral correlates of sedentary behaviors, but that the occupational variables (employment type and PA at the job) as well as the limited research has been conducted on the cognitive, social, or environmental categories are relatively under researched [53]. A 4 year follow up study by Ding et al. adds that adults with lower educational attainment, adults with lower occupational and transport physical activity, men with higher domestic physical activity, and nonworking adults living in lowly walkable neighborhoods were at higher risk of increase in TV viewing time [54].

Evidence for Elderly

For older adults, who are known to be the most sedentary population group, many studies have investigated the impact of sedentary lifestyle on health [55, 56]. Still to date not many researchers have investigated the relationship between sedentary behavior and overweight/obesity among elderly.

How to Reduce Sedentary Behavior?

The developing and emerging evidence on the relation between sedentary behavior, its correlates and moderators and overweight/obesity calls for action at intervention and policy level.

Interventions that aim to reduce sedentary behavior can focus on various settings, such as the clinical setting, the work, school and transport setting, and the home environment. Intervention strategies can for example focus on breaking up

sitting time, limiting screen time, rewarding less sedentary time, creating awareness and developing educational materials. To date, however, the number of intervention studies and studies about the efficacy of intervention is still quite small and mostly focuses on youth [5••, 9].

An intervention review by O'Connell et al. assessed 16 intervention studies targeting youth of which four were clinic based, nine community/population based and three laboratory based. They found mixed results, but detected a trend for reducing sedentary behavior [57]. Another review examined intervention studies focusing on changing sedentary behavior in youth for weight control purposes. Despite inconsistencies in significance, all included interventions reduced sedentary behavior and improved markers of weight status [58]. A meta-analysis by Biddle et al. about sedentary behavior interventions in young people concluded that the interventions produce a small reduction in sedentary behavior in children, with a larger effect for community based interventions and interventions assessing sedentary behavior with both objective and subjective methods [9]. Experimental studies by Epstein et al. showed that obese children who were stimulated to spend less time sedentary showed equal or better changes in weight than those only being reinforced to be more physical active. Also for obese children that replaced sedentary time for physical activity time positive results in terms of weight control have been found [59–61].

Little evidence is available about sedentary behavior intervention for adults. The review by the Department of Health found two interventions that aimed at increasing walking and therewith decreasing sedentary time, only one of the studies found a small decrease in sitting time [5••, 62, 63]. Another intervention they included focused on reducing family TV viewing time including both children and parents and found that half of the families achieved the intervention goal [64].

Despite the growing evidence on the health impacts of sedentary behavior and especially its relationship with overweight/obesity, up to now, not much of this proof has been adopted into national and international policy measures and recommendations on reducing sedentary behavior and particular screen time [5••, 9].

The few countries that did integrate specific recommendations on reducing sedentary behavior in their public health, obesity or physical activity programs have mostly defined guidance for young people. The Physical Activity Guide from the Australian Government (2005) for examples specifies that children should not spend more than 2 hours a day using electronic media entertainment, particularly during daylight hours [65–67]. A similar recommendation is given in Canadian guidelines for the early years, children and youth including guidance on limiting sedentary transport [68–71]. Additionally, the Public Health Agency of Canada includes tips on reducing screen time in their physical activity recommendation for all age groups [72]. The French National Nutrition and Health Programme 2011-2015 does not state a specific time limit on sedentary activity for young people, but recommends limiting the time spent in sedentary occupations, especially for children [73].

International organizations like the World Health Organization and the European Union have developed obesity action plans, NCD action plans and recommendations on physical activity but have not yet integrated specific guidelines on sedentary behavior [1, 2, 4, 7, 8, 10]. The absence of sedentary time recommendations is mostly due to the scarcity of concrete evidence to support clearly defined guidance on a maximum amount of daily sedentary time. For future public health initiatives it is crucial that the growing base of confirmatory evidence gets translated into policy development and action.

Discussion and Conclusion

Many studies point out the various health hazards associated with sedentary behavior. Evidence is accumulating that sedentary behavior forms a distinct risk factor for various adverse health outcomes. Consistent relationships have been found for the relationship between sedentary behavior and premature mortality, specifically all-cause and CVD related mortality. Extensive research also shows a consistent relationship between sedentary time and incidence of cancer, cardiovascular diseases and diabetes.

Over the last decade many studies have investigated the impact of sedentary behavior on overweight/obesity. For youth inconsistent findings are found, with some studies finding strong positive associations and others finding no association. Based on the small to moderate significant relationship between TV viewing in childhood and adult obesity it is possible to plead for a recommendation on reducing screen time, but not enough evidence has been found to quantify it in terms of time. In relation to adults the association between the gain of bodyweight or development of obesity and sedentary behavior is not clear. Again the available data does not give sufficient evidence yet to define a quantitative recommendation on daily sedentary time for preventing obesity and maintain weight. Furthermore, for both youth and adults much research has been done concerning the correlates of sedentary behavior. Various correlates have been identified, however more research is needed to identify key factors that should be targeted in strategies.

Interventions targeting obesity prevention by reducing sedentary behavior in youth show promise, but for adults currently there is a lack of evidence concerning interventions targeting sedentary behavior. For future development of successful behavior change interventions more evidence on the drivers and the factors that facilitate, motivate or reinforce sedentary behavior is needed. In order to reveal whether the impacts of sedentary behavior interventions on health outcomes remain over time it is also advisable to invest in longitudinal studies.

Despite the inconsistent findings on the impact of sedentary behavior and overweight/obesity, the current trend of spending increased time in sedentary behaviors and the studies that did conclude on a positive association make a strong argument for integrating sedentary behavior guidelines in future policy plans, recommendations and actions. As mentioned before at present it is not possible to quantify reducing sedentary time, nonetheless recommendations could spearhead bringing down the total amount spend in sedentary time, breaking up sitting time and promoting alternatives for sedentary behaviors.

Sedentary behavior research has so far mainly focused on screen time. In future research the study of sedentary behavior should go beyond traditional media based behavior and also take modern media (gaming, computer use), sitting for other purposes (reading, homework), and motorized transport more into account. Future research and intervention development has to anticipate the multifaceted character of sedentary behavior and take the age and gender differences into account.

The available data is limited by the fact that in most of the studies sedentary behavior was mainly assessed with various forms of self-report. In case of objective measurement, the use of different cut-offs complicates data comparability. Furthermore for the available data inconsistencies are identified for the approaches used to account for confounding variables [5••]. Given the limited evidence this paper was not able to present data on the relationship between sedentary behavior and older adults.

Disclosure Conflicts of interest: L. Middelbeek: has received a consultancy fee paid by World Health Organization Regional Office for Europe, Copenhagen for working on this review; is currently employed as a Staff Member for Netherlands Institute for Sport and Physical Activity; J. Breda: none. J.B. is a staff member of the WHO Regional Office for Europe. The author alone is responsible for the content and writing of this paper, which does not necessarily represents the decisions, policy or views of the WHO.

References

Papers of particular interest, published from 2009 to present, have been highlighted as:

- • Of importance
- •• Of major importance

1. World Health Organization Regional Office for Europe. WHO European Action Plan for Food and Nutrition 2007–2012. World Health Organization Regional Office for Europe: Copenhagen 2006.
2. World Health Organization Regional Office for Europe. Challenge of Obesity in the WHO European Region and the strategies for response. Copenhagen: World Health Organization Regional Office for Europe; 2012. 2007.
3. World Health Organization Regional Office for Europe website. Obesity. Available at: http://www.euro.who.int/en/what-we-do/health-topics/noncommunicable-diseases/obesity. Accessed on 26 October 2012.
4. World Health Organization Regional Office for Europe. Action Plan for Implementation of the European Strategy for the Prevention and Control of Noncommunicable Diseases 2012–2016. Copenhagen: World Health Organization Regional Office for Europe; 2011.
5. •• Department of Health, Department for Children, Schools and Families. Sedentary behavior and obesity: review of the current scientific evidence. London: Department of Health; 2010. *In this paper the Sedentary Behavior and Obesity Expert Working Group explores the evidence linking sedentary behavior with health outcomes, in particular overweight/obesity, describes what has been done at intervention and policy level and investigates whether there is sufficient evidence to make recommendations on reducing sedentary time*.
6. Sedentary Behavior Research Network. Letter to the editor: standardized use of the term "sedentary" and "sedentary behaviors". Appl Physiol Nutr Metab. 2012;37(3):540–2.
7. World Health Organization. Global strategy on diet, physical activity and health. Geneva: World Health Organization; 2004.
8. European Commission. Strategy on nutrition, overweight and obesity-related health issues. Brussels: European Commission; 2007.
9. Biddle SJ, O'Connell S, Braithwaite RE. Sedentary behavior interventions in young people: a meta-analysis. Br J Sports Med. 2011;45(11):937–42.
10. World Health Organization. Global recommendations on physical activity for health. Geneva: World Health Organization; 2010.
11. Yates T, Gorely T, Khunti K. Letters to the editor: sedentary behavior, what's in a definition? Am J Prev Med. 2011;40(6):e33–4.
12. Owen N. Sedentary behavior: understanding and influencing adults' prolonged sitting time. Prev Med. 2012. doi:10.1016/j.ypmed.2012.08.024.
13. 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):384–91.
14. Grøntved A, Hu FB. Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality. JAMA. 2011;305(23):2448–55.
15. Biddle SJH, Gorely T, Marshall SJ, et al. Physical activity and sedentary behaviors in youth: issues and controversies. J R Soc Promot Health. 2004;124(1):29–33.
16. Tremblay MS, Colley RC, Saunders TJ, et al. Physiological and health implications of a sedentary lifestyle. Appl Physiol Nutr Metab. 2010;35(6):725–40.
17. Morris JN, Heady JA, Raffle PAB, et al. Coronary heart-disease and physical activity of work. Lancet. 1953;2(1053–1057):1111–20.
18. • Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet. 2012;380(9838):247–57. *This paper gives an overview of global and regional physical inactivity and sedentary behavior levels and outlines surveillance pitfalls and prospects*.
19. Chastin SFM, Granat MH. Methods for objective measure, quantification and analysis of sedentary behavior and inactivity. Gait Posture. 2010;82–6.
20. Currie C, et al. Social determinants of health and well-being among young people. Health Behavior in School-aged Children (HBSC) study: international report from the 2009/2010 survey. Copenhagen: WHO Regional Office for Europe; 2012.
21. Brug J, van Stralen MM, te Velde SJ, et al. Differences in weight status and energy-balance related behaviors among schoolchildren across Europe: the ENERGY-Project. PLoS One. 2012;7(4):e34742.

22. Mitchell JA, Mattocks C, Ness AR, et al. Sedentary behavior and obesity in a large cohort of children. Obesity. 2009;17:1596–602.
23. Biddle SJH, Gorely T, Marshall SJ, et al. The prevalence of sedentary behavior and physical activity in leisure time: a study of Scottish adolescents using ecological momentary assessment. Prev Med. 2009;48:151–5.
24. Hamar P, Biddle S, Soos I, et al. The prevalence of sedentary behaviors and physical activity in Hungarian youth. Eur J Pub Health. 2009;20(1):85–90.
25. Gordon-Larsen P, Nelson MC, Popkin BM. Longitudinal physical activity and sedentary behavior trends: adolescence to adulthood. Am J Prev Med. 2004;27(4):277–83.
26. European Commission. Eurobarometer 64.3. Special Eurobarometer 246: health and food. Brussels: European Commission; 2006.
27. Bauman A, Ainsworth BE, Sallis JF, et al. The descriptive epidemiology of sitting a 20-country comparison using the international physical activity questionnaire (IPAQ). Am J Prev Med. 2011;41:228–35.
28. Jans PM, Proper IP, Hildebrandt VH. Sedentary behavior in Dutch workers: differences between occupations and business sectors. Am J Prev Med. 2007;33(6):450–4.
29. Thorp AA, Owen N, Neuhaus M, et al. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996-2011. Am J Prev Med. 2011;41(2):207–15.
30. • Dunstan DW, Howard B, Healy GN, et al. Too much sitting: a health hazard. Diabetes Res Clin Pract. 2012;97(3):368–76. *This paper reviews the health impacts of sedentary behavior and makes a case that the adverse health outcomes of too much sitting should now be considered an important stand-alone component of the physical activity and health equation*.
31. • Proper KI, Singh AS, van Mechelen W, et al. Sedentary behaviors and health outcomes among adults: a systematic review of prospective studies. Am J Prev Med. 2011;41(2):207–15. *This systematic review presents an accurate evidence synthesis describing the relation between sedentary behavior and body weight/BMI gain, overweight/obesity, waist gain, type 2 diabetes, cardiovascular disease risk factors, endometrial cancer and mortality in adults*.
32. Hancox RJ, Milne BJ, Poulton R. Association between child and adolescent television viewing and adult health: a longitudinal birth cohort study. Lancet. 2004;364(9430):257–62.
33. Viner RM, Cole TJ. Television viewing in early childhood predicts adult body mass index. J Pediatr. 2005;147(4):429–35.
34. Marshall SJ, Biddle SJH, Gorely T, Cameron N, Murdey I. Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. Int J Obes. 2004;28:1238–46.
35. Rey-Lopez JP, Vicente-Rodriquez G, Biosca M, et al. Sedentary behavior and obesity development in children and adolescents. Nut Metab Cardiovas. 2008;18(3):242–51.
36. Hands BP, Chivers PT, Parker HE, et al. The associations between physical activity, screen time and weight from 6 to 14 yrs: the Raine Study. J Sci Med Sport. 2011;14(5):397–402.
37. Altenburg TM, Singh AS, van Mechelen W, et al. Direction of the association between body fatness and self-reported screen time in Dutch adolescents. Int J Behav Nut Phys Act. 2012;9(4).
38. • Barnett TA, O'Loughlin J, Sabiston CM, et al. Teens and screens: the influence of screen time on adiposity in adolescents. Am J Epidemiol. 2010;172(3):255–62. *This paper explores the influence of screen time on adiposity in adolescents. The longitudinal nature of this study differentiates it from most studies that are cross-sectional or limited to short follow up periods*.
39. Cillero IH, Jago R. Systematic review of correlates of screen viewing among young children. Prev Med. 2010;51(1):3–10. This paper offers a recent overview of the correlates.
40. Gorely T, Marshall S, Biddle SJH. Couch kids: correlates of television viewing among youth. Int J Behav Med. 2004;11 (3):152–63.
41. Padez C, Mourao I, Morreira P, et al. Long sleep duration and childhood overweight/obesity and body fat. Am J Hum Biol. 2009;21(3):371–6.
42. Wells JC, Hallal PC, Reichert FF, et al. Sleep patterns and television viewing in relation to obesity and blood pressure: evidence from an adolescent Brazilian birth cohort. Int J Obes. 2008;32(7):1042–9.
43. Kuriyan R, Bhat S, Thomas T, et al. Television viewing and sleep are associated with overweight among urban and semi-urban South Indian children. Nutr J. 2007;6:25.
44. Sammel MD, Grisso JA, Freeman EW, Hollander L, Liu L, Liu S, et al. Weight gain among women in the late reproductive years. Fam Pract. 2003;20:401–9.
45. Blanck HM, McCullough ML, Patel AV, et al. Sedentary behavior, recreational physical activity, and 7 year weight gain among postmenopausal U.S. women. Obesity. 2007;15:1578–88.
46. Ekelund U, Brage S, Besson H, Sharp S, Wareham NJ. Time spent being sedentary and weight gain in healthy adults: reverse or bidirectional causality? Am J Clin Nutr. 2008;88(3):612–7.
47. Ball K, Brown W, Crawford D. Who does not gain weight? Prevalence and predictors of weight maintenance in young women. Int J Obes. 2002;26:1570–8.
48. Hu FB, Li TY, Golditz GA, et al. Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. JAMA. 2003;289(14):1785–91.
49. Van Uffelen JG, Wong J, Chau JY, et al. Occupational sitting and health risks: a systematic review. Am J Prev Med. 2010;39(4):379–88.
50. Cameron AJ, Welborn TA, Zimmet PZ, et al. Overweight and obesity in Australia: the 1999–2000 Australian diabetes, obesity and lifestyle study (AusDiab). Med J Aust. 2003;178(9):427–32.
51. Salmon J, Bauman A, Crawford D, et al. The association between television viewing and overweight among Australian adults participating in various levels of leisure-time physical activity. Int J Obes Relat Metab Disord. 2000;24(5):600–6.
52. Ding D, Sugiyama T, Owen N. Habitual active transport, TV viewing and weight gain: a four year follow-up study. Prev Med. 2012;54(3–4):201–4.
53. Rhodes RE, Mark RS, Temmel CP. Adult sedentary behavior: a systematic review. Am J Prev Med. 2012;24(3):e3–e28.
54. Ding D, Sugiyama T, Winkler E, et al. Correlates of change in adults' television viewing time: a four-year follow-up study. Med Sci Sports Exerc. 2012;44(7):1287–92.
55. Gardiner PA, Clark BK, Healy GN, et al. Measuring older adults' sedentary time: reliability, validity, and responsiveness. Med Sci Sports Exerc. 2011;43(11):2127–33.
56. Phillips EM, Schneider JC, Mercer GR. Motivating elders to initiate exercise. Arch Phys Med Rehabil. 2004;85(3):52–7.
57. Biddle SJ, O'Connell S, Braithwaite RE. Sedentary behaviour interventions in young people: a meta-analysis. Br J Sports Med. 2011;45(11):937-42. doi:10.1136/bjsports-2011-090205. Epub 2011 Aug 1.
58. DeMattia L, Lemont L, Meuer L. Do interventions to limit sedentary behaviours change behavior and reduce childhood obesity? A critical review of the literature. Obes Rev. 2007;8(1):69–81.
59. Epstein LH, Roemmich JN. Reducing sedentary behavior: role in modifying physical activity. Exerc Sport Sci Rev. 2001;29(3): 103–8.
60. Epstein LH, Paluch RA, Gordy CC, Dorn J. Decreasing sedentary behaviors in treating pediatric obesity. Arch Pediatr Adol Med. 2000;154(3):220–2.
61. Epstein LH, Valoski AM, Vara LS, McCurley J, Wisniewski L, Kalarchian MA, et al. Effects of decreasing sedentary behaviour and increasing activity on weight change in obese children. Health Psychol. 1995;14:109–15.
62. Gilson N, Puig-Ribera A, McKenna J, et al. Do walking strategies to increase physical activity reduce reported sitting in workplaces? A randomized control trial. Intl J Behav Nutr Phys Act. 2009;6:43.

63. Gorin A, Raynor H, Chula-Maguire K, et al. Decreasing household television time: a pilot study of a combined behavioral and environmental intervention. Behav Intervent. 2006;21:273–80.
64. De Cocker KA, De Bourdeaudhuij IM, Brown WJ, et al. The effect of a pedometer-based physical activity intervention on sitting time. Prev Med. 2008;47(2):179–81.
65. Australian Government. Department of Health and Aging. Active Kids are healthy kids: Australia's physical activity recommendations for 5–12 year olds. Canberra: Australian Government, Department of Health and Ageing; 2004.
66. Australian Government, Department of Health and Aging. National Physical Activity Guidelines for Australians. Available at: http://www.health.gov.au/internet/main/publishing.nsf/content/health-pubhlth-strateg-phys-act-guidelines. Accessed on 26 October 2012.
67. Tremblay MS, Leblanc AG, Jansen I, et al. Canadian sedentary behaviour guidelines for children and youth. Appl Physiol Nutr Metab. 2011;36(59–64):65–71.
68. Spanier PA, Marshall SJ, Faulkner GE. Tackling the obesity pandemic: a call for sedentary behavior research. Can J Pulicb Health. 2006;97(3):255–7.
69. Canadian Society for Exercise Physiology. Canadian sedentary behavior guidelines: for the early years 0–4. Ottowa: Canadian Society for Exercise Physiology.
70. Canadian Society for Exercise Physiology. Canadian sedentary behavior guidelines: for children 5–11 years. Ottowa: Canadian Society for Exercise Physiology.
71. Canadian Society for Exercise Physiology. Canadian sedentary behavior guidelines: for youth 12–17 years. Ottowa: Canadian Society for Exercise Physiology.
72. Public Health Agency of Canada. Physical Activity guidelines and tips to get active. Available at: http://www.phac-aspc.gc.ca/hp-ps/hl-mvs/pa-ap/index-eng.php. Accessed on 26 October 2012.
73. Ministry of Health. National Nutrition & Health Programme (PNNS) 2001 2005. Paris: Ministry of Health; 2011.