



1

**General
Introduction**

Physical activity (PA) and sedentary behavior are independent health risk behaviors (1,2). PA in children is of great importance, as it has positive effects on musculoskeletal health, cardiovascular health, adiposity, as well as mental health and academic performance (3). Sedentary behavior (SB) is not the mirror behavior of PA, but is considered as another distinct behavior and defined as activities that require low energy expenditure and primarily performed while sitting (e.g., watching television, playing computer and video games) (4). Evidence on the influence of prolonged periods of SB on children's health is inconsistent but accumulating (5,6). Current guidelines suggest that school-aged children should participate in at least 60 minutes of moderate- to vigorous-intensity PA daily (7). Although strong evidence for SB guidelines is lacking they have been formed in Canada and the UK (8,9). A recent cross-European school survey that objectively assessed PA showed that only 17% of boys and 5% of girls aged between 10-12yr comply with the current PA guidelines (10). Moreover, children spend daily an average of six to eight hours in sedentary activities (10,11).

A low level of PA, combined with excessive sedentary time is associated with increased risk of overweight/obesity in youth (5,12). Being overweight/obese has adverse effects on children's current and future health, as it is very likely that overweight during childhood tracks into adulthood (13). Childhood obesity prevalence is at an alarming level and prevention is required to reverse the obesity epidemic (14,15).

The Battle against Obesity; Prevention interventions

Prevention programs should target the most important behaviors and their modifiable determinants. They should be theory and evidence-based in order to achieve the largest effects (16). Next to PA and SB there are some key dietary behaviors that are triggering excessive weight gain among youth and relevant for obesity prevention studies including sugar-containing beverages intake, high caloric snack consumption, breakfast consumption and fast-food intake (17-19).

Weight gain prevention should preferably start at an early age, because overweight and obesity track very strongly from childhood to later age, and healthy behaviors that are learned early in life are somewhat more likely maintained in adulthood (20). Therefore, school-aged children are an important target population for obesity prevention. Schools are an ideal setting to reach children for promotion of healthy behaviors (21). However, a recent integrative review showed mixed effects of school-based interventions targeting energy balance-related behaviors (EBRBs) and body weight change (22). One in three school-based interventions resulted in significant (rather small) changes in children's overweight status or body mass index (BMI). The need for high-quality research to focus on identifying specific program characteristics predictive of success was highlighted (22,23).

Toward a better understanding of school-based interventions; Mediators and Moderators

In the field of childhood obesity prevention the main focus is on weight status. However, besides testing whether the intervention works or not it is crucial to examine how it works

and for whom it works (24,25). The identified effective important intervention components could be intensified and refined, while the irrelevant components could be eliminated, which may also improve the cost-effectiveness of interventions (24). In order to identify successful intervention components, researchers should apply more detailed analysis. Mediation and moderation analysis can be used to investigate these underlying mechanisms.

A mediator is an intermediate causal variable that lies between a predictor and the outcome. In other words, a predictor causes the mediating variable which then causes the outcome variable (26). As shown in Figure 1 an intervention may influence the outcome variable (e.g., weight status) via changing the mediator (e.g., PA, diet). Mediating effects can be investigated by three consecutive tests; a) the action theory test, that refers to how the intervention changes the hypothesized mediator (path a in Figure 1); b) the conceptual theory test, that refers to how the hypothesized mediator influences the outcome variable while adjusting for the intervention (path b in Figure 1); c) testing the mediating effect, which is the simultaneous testing of action and conceptual theories (26).

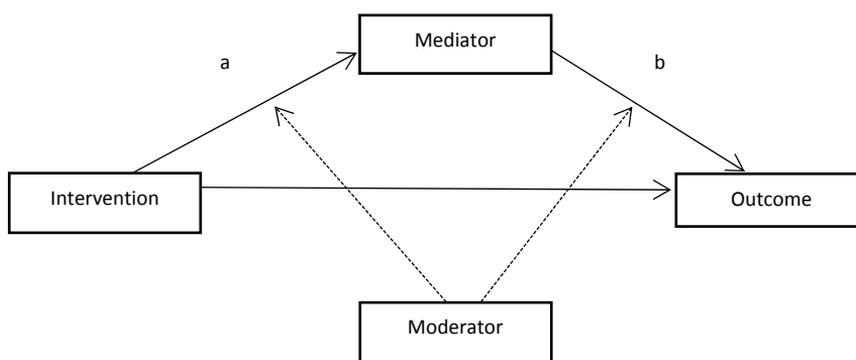


Figure 1. A conceptual framework of mediating and moderating effects.

Moderators are variables that may enhance, reduce or directionally change the predictor-outcome relationship. That is, the effect of an independent variable on individual participants depends on the level/value of the moderator (24). Figure 1 shows that in a mediation model, moderating effects can be investigated both on the intervention effect on a hypothesized mediator and/or on the relationship between the mediator and the outcome. By evaluating moderating effects of an intervention, one can estimate the needs of a specific subgroup in the target population. Moderators of an intervention effect can be socio-demographic characteristics of the participants (e.g., gender, age, ethnicity), the circumstances under which the intervention is delivered (e.g., site or setting), components that are manipulated by the intervention (e.g., family involvement) and psychological variables (e.g., intention, attitude) (27).

Who, What, Why and Where do we go from here?

Considering the limited success of previous school-based obesity prevention interventions we need to recognize the key gaps in our knowledge about factors influencing the effectiveness of school-based obesity prevention programs. Some of the problems related to the limited success include;

1. targeting behaviors that were not related to excess weight gain or adiposity in youth;
2. targeting mediating variables that were not related to or suppressed the behavior change;
3. being unsuccessful in changing the potential mediators;
4. failing to consider the needs of the subgroups;
5. applying inadequate measurement of the behavior and/or mediators hindered identifying significant relationships;
6. failing to carefully consider social and physical environmental determinants of EBRBs.

This thesis aimed to contribute to filling the knowledge gap in above-mentioned issues. It is obvious that EBRBs are complex behaviors influenced by multiple factors. This thesis explores childhood obesity related EBRBs, and the personal, social and environmental determinants of EBRBs. Furthermore, this thesis discusses the measurement issues of PA and SB using accelerometers, because without accurate measurement of PA and SB, identifying the determinants of these behaviors is difficult.

Aim and outline of the thesis

The aim of this thesis was three fold;

1. to explore the mediating and moderating mechanisms of school-based obesity prevention interventions targeting EBRBs;
2. to explore measurement issues of PA and SB using accelerometers;
3. to address social and environmental determinants of EBRBs.

Part 1 and 2 of this thesis focus on working mechanisms (what works, why, and for whom) of school-based obesity prevention interventions. Chapter 2 evaluates longitudinal working mechanisms of the Dutch Obesity Intervention in Teenagers (DOIT). It is an example of an investigation on mediating effects of the EBRBs on changes in adiposity measures in a school-based intervention study. By longitudinal mediation analysis the temporal sequence of the relationships as well as the trajectory of the change over time was explored. Chapter 3 and 4 describe systematic reviews of moderators and mediators, respectively, of school-based interventions targeting EBRBs.

Part 3 describes the objective measurement of PA and SB using accelerometers. Chapter 5 describes the study protocol of the accelerometer sub-study in the European Commission funded ENERGY project (www.projectenergy.eu) (28). It critically appraises the best evidence for the decisions on data collection and data processing with accelerometers. There is a lack of evidence regarding the influence of cut-off point decisions on SB time.

Therefore, Chapter 6 examines the appropriateness of the existing accelerometer cut-off points for SB measurement.

Part 4 describes the social and environmental determinants of EBRBs. There is a shift in research to use ecological models to explain multiple dimensions on factors that influence behavior (intrapersonal, sociocultural and environmental) (29). In Chapter 7 EBRBs and weight status of Turkish immigrant adolescents living in the Netherlands and their Turkish compatriots living in Turkey are compared. In Chapter 8 the influence of weather on children's PA and SB in the ENERGY study is examined. Chapter 9 discusses the interpersonal and environmental mediators of the mid-intervention effects on PA during school recess and lunchtime in the Transform-Us! study.

Finally, Chapter 10 concludes by discussing the main findings of the thesis, the important methodological issues and provides recommendations for future research.

References

1. Ekelund U, Luan J, Sherar JB, Esliger DW, Griew P, Cooper A, et al. Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA* 2012;307(7):704-712.
2. Healy GN, Wijndaele K, Dunstan DW, Shaw JE, Salmon J, Zimmet PZ, et al. Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Diabetes Care* 2008;31(2):369-371.
3. Strong WB, Malina RM, Blimkie CJR, Daniels SR, Dishman RK, Gutin B. Evidence based physical activity for school-aged youth. *J Pediatrics* 2005;146(6):732-737.
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. Tremblay MS, LeBlanc AG, Kho Me, Saunders TJ, Larouche R, Colley RC, et al. Systematic review of sedentary behavior and health indicators in school-aged children and youth. *Int J Behav Nutr Phys Act* 2011;8:98.
6. Chinapaw MJM, Proper KI, Brug J, van Mechelen W, Singh AS. Relationship between young peoples' sedentary behavior and biomedical health indicators: a systematic review of prospective studies. *Obes Rev* 2011;12(7):e621-e632.
7. World Health Organization. *Global Recommendations for Physical Activity and Health*. Geneva: WHO, 2010.
8. Tremblay MS, LeBlanc AG, Janssen I, Kho ME, Hicks A, Murumets K, et al. Canadian sedentary behavior guidelines for children and youth. *Appl Physiol Nutr Metab* 2011;36(1):59-64; 65-71.
9. The Department of Health, the UK. *Start active, stay active: a report on physical activity for health from the four home countries' Chief Medical Officers*. 2011.
10. Verloigne M, Van Lippevelde W, Maes L, Yildirim M, Chinapaw M, Manios Y, et al. Levels of physical activity and sedentary time among 10- to 12-year-old boys and girls across 5 European countries using accelerometers: an observational study within the ENERGY-project. *Int J Behav Nutr Phys Act* 2012;9:34.
11. Matthews CE, Chen KY, Freedson PS, Buchowski MS, Beech BM, Pate RR, et al. Amount of time spent in sedentary behaviors in the United States, 2003-2004. *Am J Epidemiol* 2008;167(7):875-881.
12. Must A, Tybor DJ. Physical activity and sedentary behavior: a review of longitudinal studies of weight and adiposity in youth. *Int J Obes* 2005;29(Suppl 2):84-96.
13. Singh AS, Mulder C, Twisk JWR, Van Mechelen W, Chinapaw MJM. Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obes Rev* 2008;9:474-488.
14. Branca F, Nikogosian H, Lobstein T. *The challenge of obesity in the WHO European Region and the strategies for response*. World Health Organization 2007. Denmark.
15. Ogden C, Carroll M, NCHS Health E-Stat. *Prevalence of Obesity Among Children and Adolescents: United States, Trends 1963-1965 Through 2007-2008*. Accessed 23-09-2012.
16. Lloyd JJ, Logan S, Greaves CJ, Wyatt KM. Evidence, theory and context - using intervention mapping to develop a school-based intervention to prevent obesity in children. *Int J Behav Nutr Phys Act* 2011;8:73.
17. Laska MN, Murray DM, Lytle LA, Harnack LJ. Longitudinal Associations Between Key Dietary Behaviors and Weight Gain Over Time: Transitions Through the Adolescent Years. *Obesity* 2012;20:118-125.
18. James J, Kerr D. Prevention of childhood obesity by reducing soft drinks. *Int J Obes* 2005;29:54-57.
19. Davis MM, Gance-Cleveland B, Hassink S, Johnson R, Paradis G, Resnicow K. Recommendations for prevention of childhood obesity. *Pediatrics* 2007;120:229-253.
20. Frech A. Healthy behavior trajectories between adolescence and young adulthood. *Adv Life Course Res* 2012;17(2):59-68.
21. Harrison F, Jones AP. A framework for understanding school based physical environmental influences on childhood obesity. *Health Place* 2012;18(3):639-648.
22. Safron M, Cislak A, Gaspar T, Luszczynska A. Effects of School-based Interventions Targeting Obesity-Related Behaviors and Body Weight Change: A Systematic Umbrella Review. *Behav Med* 2011;37(1): 15-25.
23. Khambalia AZ, Dickinson S, Hardy LL, Gill T, Baur LA. A synthesis of existing systematic reviews and meta-analyses of school-based behavioral interventions for controlling and preventing obesity. *Obes Rev* 2012;13:214-233.

24. Kraemer HC, Wilson GT, Fairburn CG, Agras WS. Mediators and moderators of treatment effects in randomized clinical trials. *Arch Gen Psychiatry* 2002;59(10):877-833.
25. Baranowski T. Editorial: School-based obesity-prevention interventions in low- and middle-income countries: do they really work? *Am J Clin Nutr* 2012;96:227-228.
26. MacKinnon DP. *Introduction to Statistical Mediation Analysis*. New York: Taylor & Francis Group; 2008.
27. Aguinis H. *Regression analysis for categorical moderators*. 1st ed. New York: The Guilford Press; 2004.
28. Brug J, te Velde SJ, Chinapaw MJM, Bere E, de Bourdeaudhuij I, et al. Evidence-based development of school-based and family-involved prevention of overweight across Europe: The ENERGY-project's design and conceptual framework. *BMC Public Health* 2010;10:276.
29. Stanley RM, Ridley K, Dollman J. Correlates of children's time-specific physical activity: A review of the literature. *Int J Behav Nutr Phys Act* 2012;9:50.

