ACTIVE VIDEO GAMES

Can they contribute to the prevention of excessive weight gain in gaming adolescents?

Monique Simons

Active video games

Body@Work

Monique Simons

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eMGO+ Institute for Health and Care Research

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Contents

CHAPTER 1
General introduction

The overall aim of this thesis is to evaluate whether providing video games that require physical activity to play –hereafter called active (video) games– in the home setting, can contribute to prevention of excessive weight gain in gaming adolescents by reducing sedentary behavior and increasing physical activity. In this general introduction a rationale will be given for the research presented in this thesis by following the first three steps of the model for planned promotion of population health [1;2], as shown in Figure 1. First, the health problem is being analyzed, namely overweight and obesity in adolescents, by describing the prevalence and the importance to target this health problem (step 1: analysis of health and disease). Next, the most important underlying behaviors of overweight and obesity (step 2: analysis of behavior) are being described and it is being highlighted why adolescents form an important target group for overweight prevention interventions. Further, the determinants of these overweight-related behaviors are being described using two relevant theoretical approaches (step 3: analysis of determinants of behavior). Hereafter, it is explained why video games –and in particular active games– seem a promising a tool for health promotion and prevention of overweight. Finally, a short description of the studies that have been conducted within this thesis is given.

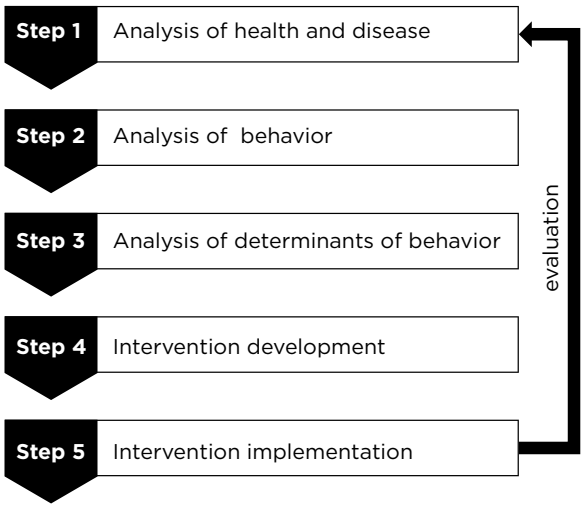

Figure 1: Model for planned health promotion (Based on Brug et al. [1] and Green and Kreuter [2]

Problem analysis

Overweight in youth is a major public health concern [3-5]. The most recent edition of the Dutch nation-wide growth study showed that in 2009, 13% of the Dutch boys and 15% of the Dutch girls aged 2–21 years were overweight while 1.8% of the boys and 2.2% of the girls were obese [5]. Compared to 1980, this overweight prevalence is two to three times as high and the obesity prevalence four to six times as high. In the United States overweight and obesity rates are even higher, with 32% of 2-19 years old youth being either overweight or obese, and 17% being obese in 2011-2012 [3].

Youth overweight and obesity are associated with negative physical and psychological consequences. Overweight and obesity increases risk for high blood pressure, diabetes mellitus type 2, elevated LDL- cholesterol, depressive symptoms and low self-esteem during childhood itself [6]. Next, overweight and obesity often track into adulthood [7-9], contributing to higher risks for health problems later in life such as cardiovascular disease, hypertension, diabetes mellitus type 2 and premature mortality [10-12]. All these health risks make overweight a major burden of disease and health care spendings [13-15].

Although there are many programs aimed at treatment of overweight and obesity, results have often been disappointing, especially regarding long-term effectiveness [16]. Therefore, an important strategy is to prevent excessive weight gain (i.e., weight gain that exceeds weight gain caused by regular growth) and in this way thus prevent the development of overweight and obesity [17;18].

Physical activity, sedentary behavior and energy intake

Overweight is the consequence of excessive weight gain, caused by a long-term positive energy balance, i.e., when energy intake is larger than energy expenditure. The underlying mechanisms of becoming overweight are complex and involve besides genetic and hormonal factors, also cognitive, motivational, behavioral and environmental factors [19]. An important way to contribute to the prevention of excessive weight gain is to encourage behaviors that increase energy expenditure and reduce energy intake, in other words restoring the energy balance. Important energy balance-related behaviors are physical activity, sedentary behavior and energy intake, which will be explained below.

Physical activity

Physical activity is a main modifiable contributor to energy expenditure, making increasing and promoting physical activity of major importance for maintaining a healthy body weight and prevention of overweight [20-23]. However, many children have a low

level of physical activity [24-26]. The Dutch moderate intense physical activity guideline for children recommends at least 60 minutes of moderate-to-vigorous physical activity a day but only 18% of children meet this guideline [24]. Moreover, a marked decrease in physical activity is observed during adolescence making it a critical life stage for physical activity promotion [27;28].

Sedentary behavior

Furthermore, sedentary behavior –especially too much and prolonged sitting activities- may have a partially independent impact on risk for obesity and cardio metabolic disease [29-33], although the evidence to date is inconclusive, especially in youth [34-35]. However, in adults there is accumulating evidence that prolonged sitting may be detrimental to health [36]. Therefore there are concerns about the excessive amount of time children spend sedentary. On average children spend around eight hours per day sedentary [24;26]. Although there is no general accepted maximal sedentary time, often the recommendation of the American Academy of Pediatrics is applied which states that children should not spend more than two hours per day in sedentary screen activities [37]. Next to watching television, playing video games is a major and increasing contributor to sedentary behavior [38-40]. In the USA, an average of almost two hours per day playing video games was reported for 8-18 year olds, with an increase of almost one hour per day from 1999 to 2009 [38]. In the Netherlands, gaming behavior peaks during adolescence, with 95% of 13–19 years old boys and 85% of the girls spending on average 10 and 4 hours per week playing video games, respectively [39].

Energy intake

It is widely acknowledged that dietary intake plays a key role in the regulation of energy balance [20]. Important modifiable contributors to energy intake are consumption of snacks and sugar-sweetened beverages. Although, the evidence is mixed [20], there are several studies showing an association between the intake of sugar-sweetened beverages and snacks and excessive weight gain in children and adolescents [41-43]. Hence, it is important to take consumption of snacks and sugar-sweetened beverages into account when investigating weight management.

Associations between energy balance-related behaviors

The different energy balance-related behaviors are not independent from each other. For example, consumption of sugar-sweetened beverages and snacks has been found to be associated with sedentary screen time [44-47]. Most of these studies focused on watching TV, but more recent evidence suggests that the same may be true for gaming. For example, Chaput et al. [48] showed that a single session of video game play in healthy male adolescents was associated with an increased food intake, regardless of appetite sensations. Furthermore, an intervention study found that energy intake decreased when sedentary behaviors (i.e., TV viewing, computer use, and video gaming) decreased in non-overweight adolescents [49]. Thus, it might be that exchanging sedentary

pastime for more active time concurs with a reduction in energy intake. Further, there are concerns that that sedentary activities pulls children away from physical activity [50-52]. However a meta-analysis showed that the association between physical activity and sedentary time is very weak or even absent [53]. These potential associations between the different energy balance-related behaviors show the importance of an integrated study of both dietary and physical activity and sedentary behavior.

Adolescents and energy balance-related behaviors

A critical life stage in the development and persistence of obesity and related co-morbidities into adulthood is adolescence [54;55]. Adolescence is a transitional phase from childhood to adulthood, during which children become more independent, where there is less parental control and an increasing peer pressure [54]. The adolescent life stage is characterized by unhealthy patterns in energy balance-related behaviors: high intake of sugar-sweetened beverages and snacks [25] a decrease in sport participation and other physical activities [27;28] and high levels of sedentary behavior [25;26]. Furthermore, during adolescence the amount and location of body fat changes a lot [54]. This all makes adolescence a critical phase for prevention of excessive weight gain. These unhealthy behaviors might not always have an acute noticeable effect during adolescence but may have a profound effect on health in later life [56], as unhealthy behavioral patterns as well as biomedical risk factors often track into adulthood [57]. As adolescence is the transition phase into adulthood, it is important to promote healthy behaviors in this life stage and not only in younger children. Healthy habits established during youth may similarly track into adulthood and beneficially affect health [31;56]. For example, a high level of physical activity adopted during youth and sustained into adulthood is thought to have beneficial effects regarding prevention of cardiovascular diseases and type 2 diabetes [58].

Thus adolescents are a very important target group for overweight prevention and health promotion strategies [54]. However, it is also a difficult group to motivate for health behavior change. Adolescents often do not perceive long term consequences of their behavior, do not see a reason to change their behavior, have little interest in health, are very much concerned about what their peers think of them, are experiencing stress because of low self-esteem, and have a powerful drive for independence and peer association [56]. These extra challenges in adolescent health promotion may have led to the fact that there are relatively few high quality intervention studies on overweight and obesity management in adolescents compared to other age groups, despite the fact that this age group is of such crucial importance for developing a healthy lifestyle and bodyweight [56].

Determinants of these energy balance-related behaviors

In order to improve energy balance-related behaviors (e.g. physical activity, sedentary behavior and energy intake), it is important to understand the underlying factors of these behaviors. Two specific theoretical approaches are relevant for understanding determinants of gaming behaviors, i.e., the Environmental Research framework for weight Gain prevention (EnRG) framework and the Self-Determination Theory.

The EnRG framework (Figure 2) describes that besides individual, cognitive and motivational factors also environmental factors play a role in energy balance-related behaviors [19]. Individual factors and environmental factors interact with each other, as the environment can influence the subjective norm or someone's attitude towards a behavior. How the individual and environmental factors influence the person's behavior, can be moderated by personal moderators (such as demographics) and behavioral moderators (such as habit strength). Further, the framework highlights that there is not a single factor that causes weight gain and overweight, but the co-existence and interaction of several dietary and physical activity behaviors causes a positive energy balance and weight gain [19].

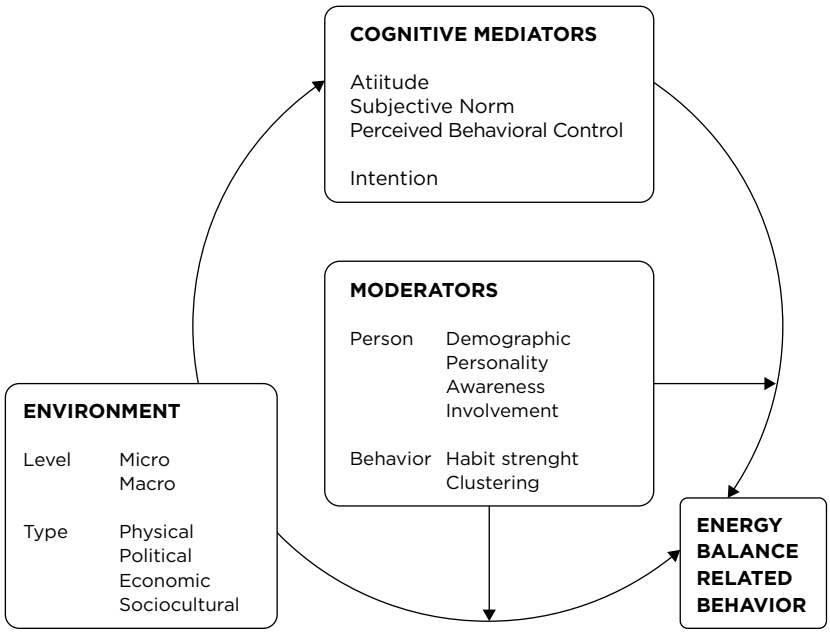

Figure 2: Environmental Research frame work for weight Gain prevention [19]

Self Determination Theory

An appropriate theory to explain why active games (which will be explained further below) hold promise in health promotion interventions is the Self Determination Theory [59]. This theory addresses the type of motivation behind behavioral choices. Intrinsic motivation refers to doing an activity because it is enjoyable and satisfying in itself, in contrast extrinsic motivation refers to doing an activity for instrumental reasons e.g. to obtain an external goal [59]. One is more likely to initiate and continue a behavior when one is intrinsically motivated [60] and therefore this type of motivation is most desirable when promoting a health behavior. Active gaming is a fun activity and adolescents may therefore be more intrinsically motivated to play these games. This is important, as it may make active gaming a promising tool for reducing sedentary time and increasing physical activity.

Potential of video games in health behavior change

Because of the above-mentioned challenges in promoting health behavior in adolescents, it is recommended to use novel and tailored approaches in adolescent health promotion research and interventions [56]. Behavior change interventions are generally believed to be more effective if they fit the interest of the target group and are based on intrinsic motivation [60]. As mentioned above, many adolescents play video games and spend a lot of time on it. Next, high sales numbers confirm how popular video games are and how big the market is; total hardware and software sales for 2008 in the US were $21.33 billion, a rise of 19% from 2007 [61]. Also, in the Netherlands the video game industry is relatively big for a small country; the Dutch video games market is expected to generate revenues of 722 million in 2017 [62].

Yet, it is clear that many adolescents are strongly appealed by video games, consequently video games seem to have a high potential to reach adolescents and may be effective in health behavior change interventions. The latter especially goes for the newest form of video gaming that has more recently emerged: active video games. Active video games directly encourage physical activity by integrating it in the gameplay. Sensors and controllers are used to capture body movements of the player, and the body movements are translated and used to play the game. This body movement component replaces the hand controller of traditional video games, which are mainly played while sitting and controlled by pushing buttons on a controller. In this thesis these traditional video games will be referred to as non-active (video) games. Studies have shown that active video games cause higher acute energy expenditure than non-active video ames and other sedentary screen activities such as watching television [63;64]. Active video games generally elicit light to moderate intensity physical activity (2–6 metabolic equivalents; METS) [63;64]. So substituting non-active gaming by active gaming, results in higher energy expenditure, which may prevent excessive weight gain.

Well-known examples of active video games are the Wii, Kinect and PlayStation Move. These commercially available active video games are developed to entertain people and sell as many products as possible, and not as an overweight prevention tool. However, this entertainment factor might also be useful to utilize in promoting healthy behaviors and there is an emerging research field that evaluates whether active video games can be used to replace non-active video games as a means for decreasing sedentary behavior and increasing physical activity in children. As competing to a highly valued activity as gaming seems unrealistic [65;66], active video games might offer an alternative and more realistic strategy.

Outline of the thesis

To explore the possible contribution of active video games to preventing excessive weight gain in gaming adolescents, we first analyzed game behavior and its correlates and then designed and evaluated an active video game intervention, based on steps 2 – 5 of the model for planned promotion of population health [1;2] (Figure 3). The chapters in this thesis addresses these steps as follows:

Part 1: Analysis of gaming behavior

We started with analyzing gaming behavior, i.e., playing active video games and non-active video games. Hereto, we conducted a cross-sectional survey in secondary schools among adolescents 1) to evaluate how many adolescents play active video games and how much time they report to spend playing them, and 2) to identify subgroups in active and non-active gaming behavior, presented in chapter 2.

Next, a 24-hour recall diary study among adolescent active video gamers who reported their activities on seven random days over a one-month period in order to get more insight into how playing active video games influences energy balance (chapter 3). This diary study sought to investigate in a naturalistic setting to what extent active video game time in everyday life' is associated with time spent in sedentary behaviors, other physical activities and consumption of snacks and sugar-sweetened drinks

Part 2: Analysis of determinants of engaging in game behaviors

Chapter 4 describes the results of a focus group study among adolescent gamers that explored adolescents´ views on active and non-active gaming and potential correlates of active gaming and non-active gaming. The specific aims were to explore adolescents' reasons for playing active and non-active games (aspects liked/not liked, preference for active or non-active games, prerequisites for long-term engagement) and the context of active and non-active gaming (when do you play, with whom, rules and restrictions at home).

The results from chapter 4 and complemented with input from health behavior theories, informed a cross-sectional survey study reported in chapter 5 among a larger group of adolescents to further study correlates of gaming in a quantitative way. The research aims of this study were to: (1) examine potential personal, social, and game-related correlates of active gaming in adolescents; and (2) examine potential personal, social, and game-related correlates of non-active gaming in adolescents; and (3) compare the correlates of active gaming with those of non-active gaming.

Part 3: Intervention development and evaluation

Chapter 6 describes the content of the active video game intervention -informed by the findings of the previous studies-, and the design and rationale of the randomized controlled trial. Next, chapter 7 presents the results of this randomized controlled trial. Effects of and adherence to the active video game promotion intervention on anthropometrics, sedentary screen time and consumption of sugar-sweetened beverages and snacks among gaming adolescents are reported. Research questions were: 1) will an active gaming promotion intervention result in a lower body mass index (BMI) adjusted for mean standard deviation score (BMI-SDS), a smaller waist circumference-SDS, hip circumference and skin fold thickness, lower self-reported time in sedentary screen activities and lower self-reported intake of sugar-sweetened beverages and snacks after four and ten months? And 2) what is the adherence to and appreciation of the active game intervention? With whom and where do they play the active games? What are potential adverse effects (occurrence of injuries because of playing with the Move games)? Which activities are being replaced by active gaming? And do the adolescents intend to continue playing the active games after the study period?

Finally, chapter 8 gives an overview of the main findings of the conducted studies, describes the broader perspective and implications of these findings and provides a critical reflection on methodological aspects. In addition, recommendations for practice and future research will be discussed.

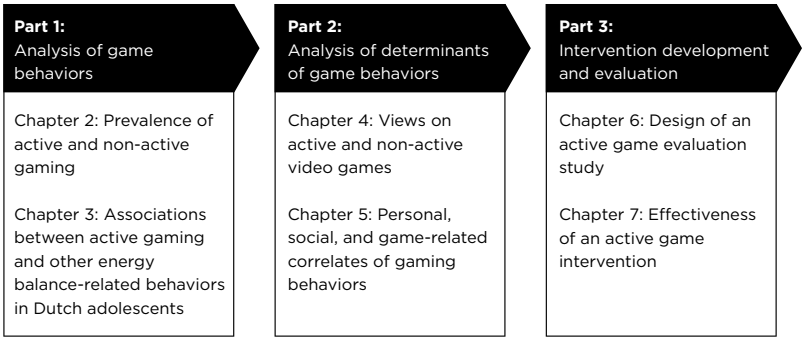

Figure 3: Outline of the thesis

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Chapter 3

Associations between active video gaming and other energy balance-related behaviors: a 24-hour recall diary study

Monique Simons
Mai Chinapaw
Johannes Brug
Jaap Seidell
Emely de Vet

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Abstract

Background

Active video games may contribute to reducing time spent in sedentary activities, increasing physical activity and preventing excessive weight gain in adolescents. Active video gaming can, however, only be beneficial for weight management when it replaces sedentary activities and not other physical activity, and when it is not associated with a higher energy intake. The current study therefore examines the association between active video gaming and other energy-balance-related behaviours (EBRBs).

Findings

Adolescents (12–16 years) with access to an active video game and who reported to spend at least one hour per week in active video gaming were invited to participate in the study. They were asked to complete electronic 24-hour recall diaries on five randomly assigned weekdays and two randomly assigned weekend-days in a one-month period, reporting on time spent playing active and non-active video games and on other EBRBs. Findings indicated that adolescents who reported playing active video games on assessed days also reported spending more time playing non-active video games (Median = 23.6, IQR = 56.8 minutes per week) compared to adolescents who did not report playing active video games on assessed days (Median = 10.0, IQR = 51.3 minutes per week, $P < 0.001$ (Mann Whitney test)). No differences between these groups were found in other EBRBs. Among those who played active video games on assessed days, active video game time was positively yet weakly associated with TV/DVD time and snack consumption. Active video game time was not significantly associated with other activities and sugar-sweetened beverages intake.

Conclusions

The results suggest that it is unlikely that time spent by adolescents in playing active video games replaces time spent in other physically active behaviours or sedentary activities. Spending more time playing active video games does seem to be associated with a small, but significant increase in intake of snacks. This suggests that interventions aimed at increasing time spent on active video gaming, may have unexpected side effects, thus warranting caution.

Introduction

Replacing non-active video games (video games that are played sedentary) with active video games (video games that require physical activity to play) may contribute to reducing time spent in sedentary activities. Thus, physical activity may be increased and excessive weight gain in adolescents may be prevented [1;2]. Playing video games is a very popular activity among adolescents; an earlier study showed that the majority of Dutch adolescents play video games and almost half play active video games [3]. Interventions aimed at increasing physical activity through the promotion of active video gaming can therefore potentially have a wide reach. Furthermore, active video gaming seems to be particularly suitable for reaching adolescents with lower levels of education. Finally, it is at least equally suitable for reaching girls as it is for reaching boys [3;4].

It is, however, unclear how active video gaming is associated with other energy-balance related behaviours (EBRBs). This is important, as active video gaming may only be beneficial for energy balance when it replaces sedentary activities such as non-active video gaming or watching TV. When adolescents play active video games instead of other physically active activities such as outdoor play or sports, active video gaming will not contribute to increasing total energy expenditure [5;6]. Another important EBRB is the consumption of snacks and sugar-sweetened beverages. Studies on non-active video gaming show that non-active game time is associated with increased energy intake through snack or soft drink consumption [7;9]. It may be that active video gaming provides less opportunity for snacking because one is physically engaged in the game. On the other hand, two laboratory studies showed that consumption of snacks and sugar-sweetened beverages during active video gaming were equal to that during non-active video gaming. In addition, a study in adults compared energy intake during active video gaming and non-active video gaming (and watching TV) and did not find any significant differences [10], nor did a study in children that compared playing non-active games while sitting with playing non-active video games while using a treadmill [11]. However, these studies only focused on energy intake during video gaming and did not evaluate energy intake during the rest of the day. It may be that active video gaming induces the intake of snacks and sugar-sweetened beverages after the activity because of thirst and hunger associated with physical activity. 'Real life' studies are limited. Therefore, the current study explores 'in real life' to what extent active video game time is associated with time spent in other physically active behaviour, sedentary activities and the consumption of snacks and sugar-sweetened drinks.

Method

A Dutch youth panel consisting of 2800 12-16-year-old adolescents with access to an active video game were invited to participate in the study and were screened for eligibility. This resulted in 596 adolescents who were willing to participate and met the criterion of spending at least one hour per week engaged in active video gaming. An active video game was defined as a video game that requires movement of the body, more than movement of the fingers and hands alone [12].

Adolescents were requested to complete electronic 24-hour recall diaries on five randomly assigned weekdays and two randomly assigned weekend days during a one-month period (April 2011), excluding holidays. On the assigned day, the adolescents were notified at 4 pm by a text message and an email which included web links to the diary. A reminder was sent the next morning at 8 am if the diary was not completed by that time. The diary could be completed until 9 am on the same day. Participants received a voucher worth 7.50 euro when all seven diaries were completed (in addition to the standard reward points system of the agency for each time they participate in a research).

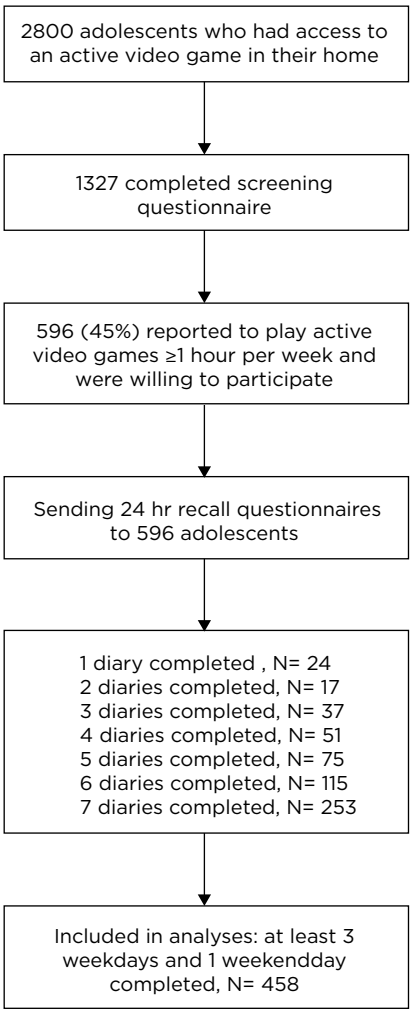

Figure 1: Flow scheme

In total 458 participants completed their diary on at least three weekdays and one weekend day, which we considered a minimum for reliable estimates, and these were included in the analyses (see Figure 1 for flow scheme).

Measurements

Demographic characteristics (age, gender, ethnicity and level of education) were assessed in the inclusion criteria screening questionnaire.

We developed an electronic 24-hour recall diary to assess engagement in and time spent on a range of EBRBs (Additional file 1). The diary used three time slots: 4:00 pm to bed time, rising time to 12:00 and 12:00 to 4:00 pm. For each time slot, adolescents were provided a list of 12 main categories of activities; 1) sleeping, 2) video gaming, 3) watching television (TV) or DVD, 4) non-video gaming computer (PC) use, 5) homework, 6) social activities, 7) other hobbies, 8) sports and active play, 9) walking and cycling, 10) other transportation, 11) household chores, and 12) work and internship. Adolescents were asked to select the activity they performed during the specific time slot and to report how many minutes they spent in that activity. In addition, the 24-hour recall diary assessed the quantity of snacks and sugar-sweetened beverages consumed during the same time slots. The mean number of minutes per day spent on each activity and mean intake per day were calculated. The questions in the diary were derived from validated questionnaires [13;17]. The questions to assess time spent playing video games were developed for the present study and are based on validated questionnaires for assessing time spent in sedentary activities [13;15;16]. The modified items were not further checked for validity.

Data handling and statistical analyses

For each time slot we calculated the total time spent on activities by adding together all reported activities in that specific time frame. We used rise time and bedtime to calculate the total number of minutes awake in each time slot. We considered single activities exceeding the total amount of possible minutes within a specific time frame as unrealistic and treated them as missing values. Multi-tasking (i.e. more than one activity at the same time) was regarded as realistic, but when the different activities added up to more than double the available minutes in a specific time slot it was regarded as missing. Next, we categorized the activities into the following nine categories: 1) active video gaming, 2) non-active video gaming, 3) watching TV/DVD, 4) PC use other than video gaming, 5) non-screen sedentary activities, 6) sports and active play, 7) other physical activities (e.g. active transportation, household chores), 8) consumption of snacks and 9) consumption of sugar-sweetened drinks (Additional file 1).

We used non-parametric tests because the data was non-normally distributed. First, time use differences between adolescents who reported active video game play (active video gamers) at assessed days and adolescents who reported no active video game play at assessed days were tested with the Mann–Whitney test. Next, Spearman correlation coefficients were computed to evaluate associations between active video gaming time on the one hand and on the other hand non-active video gaming time, TV time, non-video gaming PC time, non-screen sedentary time, sports, other physical activities and consumption of snacks and sugar-sweetened drinks. The correlation coefficients were interpreted based on Cohen's [18] guidelines ($r \geq .50$: strong association; $.30 \leq r < .50$: moderate association; $.10 \leq r < .30$: weak association). All statistical analyses were carried out using SPSS for windows, version 21.

Results

The mean age of the participants was 13.7 years (SD = 1.4), 58% were male, 98% were of Dutch ethnicity, 9% attended primary school, 43% pre-vocational secondary education and 48% higher or –pre-university secondary education.

In comparison with adolescents who did not play active games on the assessed days, the active video gamers spent significantly more time on non-active video gaming (Mann–Whitney U = 19025.5; $P < 0.001$). Time spent in other activities and consumption of snacks and sugar-sweetened beverages did not differ between the two groups (Table 1). Among the active video gamers, active video gaming time was statistically, but only weakly, positively associated with TV/DVD time ($r = 0.159$, $P = 0.047$) and consumption of snacks ($r = 0.168$, $P = 0.035$). No associations were found between active video gaming and the other EBRBs (Table 2). The mean age of the participants was 13.7 years (SD=1.4), 58% were male, 98% were of Dutch ethnicity, 9% attended primary school, 43% pre-vocational secondary education and 48% higher or pre-university secondary education.

Table 1: Median (IQR) for physical, sedentary and dietary behaviours among adolescents who did and did not play active video games at assessed days

Activity (min/day)	Adolescents who did play active video games (n=157)	Adolescents who did not play active video games (n=301)	Total group (n=458)	*P* value (Mann Whitney test)
Active video gaming	13.3 (19.9)	0	0 (8.3)	NA
Non-active video gaming	23.6 (56.8)	10.0 (51.3)	15.0 (53.6)	<0.001
Watching TV/DVD	88.6 (81.4)	94.3 (92.7)	92.1 (86.2)	0.28
Non-gaming PC use	51.4 (71.2)	51.6 (69)	51.5 (70.5)	0.96
Non-screen sedentary activities	111.4 (102.0)	110.0 (113.2)	110.4 (109.9)	0.99
Sports and active play	25.0 (51.3)	20.0 (54.6)	21.5 (54.6)	0.21
Other physical activity (> 3 METS)	38.2 (49.3)	41.3 (52.0)	40.0 (51.1)	0.59
Snacking (servings/ day)	3.1 (2.3)	3.0 (2.0)	3.0 (2.1)	0.73
Sugar-sweetened beverages (ml/day)	1107.1 (880.5)	1125.7 (971.7)	1116.6 (945.7)	0.53

IQR=interquartile range
NA= not available

Table 2: Associations (Spearman correlations) and *P*-values of time spent in active video gaming with other energy balance-related behaviours among active gamers (N=157)

	Spearman's Rho	*P* value
Non-active video gaming	0.11	0.162
Watching TV/DVD	0.16*[a]	0.047
Non-gaming PC use	0.11	0.186
Non-screen sedentary activities	0.02	0.791
Sports and active play activity (> 3 METS)	-0.03	0.680
Other physical activity (> 3 METS)	0.07	0.359
Consumption of snacks	0.17*[a]	0.035
Consumption of sugar-sweetened beverages	0.07	0.417

*Correlation is significant at the 0.05 level (2-tailed).
[a]Small effect size, (Cohen, 1988) [18]

Discussion and conclusion

Adolescents who reported playing active video games, also reported spending more time playing non-active video games than those who reported not to have played active video games. Other EBRBs did not differ between the two groups. These results suggest that an interest in active and non-active video gaming is associated, which may indicate that replacing non-active video game time for active video game time is possible. This is in line with an earlier study that showed that most adolescents who play active video games also play non-active video games [3]. However, it has also been suggested that adolescents who play video games prefer non-active video games over active video games [12] and that adolescents who play non-active video games differ from those who play active video games also in other respects [19]. These last two suggestions indicate that it may not be easy to motivate adolescents to replace non-active video gaming with active video gaming.

While active video gamers reported spending significantly more time on non-active video gaming than other adolescents, there was no significant association between the time spent on active video gaming and that spent on non-active video gaming time among the active video gamers. This may be a preliminary indication that the promotion of active video gaming would not result in a reduction of time spent on non-active video gaming. Support for this idea can be found in an earlier study that concluded that making active video games available in their home did not result in a

decrease in self-reported non-active video game time [2]. Our results also suggest that engagement in active video game play is not associated with reduced time spent on (other) physically active behaviour. However, Baranowski et al. [20] suggest that children may compensate time spent on active video gaming by being less active at other times, because no change was found in total (objectively measured) physical activity in 9–12 year olds after making active video games available in their home. Finally, our results provide some reason for concern, because engagement in active video game play was significantly associated with more TV/DVD time, consistent with the findings of O'Loughlin et al. [4], and with a higher snack intake. Also, Lyons et al. found worrying findings regarding the energy balance; people who engaged in one hour of active video gaming consumed around 400 kcal more energy than they expended [10]. Although the energy surplus of active video gaming was 273 kcal less than the energy surplus for watching TV and non-active video gaming [10], caution is still warranted when using active video games in health promotion as such an intervention may have unexpected side effects.

A limitation of the current study is the self-report of behaviour, which is prone to socially desirable answers. The questions were based on validated questionnaires for assessing energy-balance related behaviours [13;17], but were modified to target video gaming behaviour and to make them suitable for online implementation. The modified items were not further checked for validity, which is another clear limitation of the present study. Furthermore, the study is cross-sectional and not causal and no causal inference can be made. We used 24-hour recall diaries, reducing recall bias compared to questionnaires recalling a previous or usual week. Also we assessed 7 random days within a month, providing more representative data than assessing only 1 or 2 days [21]. We did not study whether the interest in playing active video games was sustained during the month, which would be of interest for further research. Moreover, this is one of the first studies investigating the extent to which active video gaming is associated with other EBRBs in everyday life. Therefore, the current study provides very important insights into whether active video games can be an effective substitute for non-active video games in terms of preventing excessive weight gain. Nevertheless, more research is needed on the association between active video gaming and energy intake to get a clearer picture on what the beneficial and unanticipated effects of an active video gaming intervention can be. In addition, it would be of interest to compare active video gaming with other physical activities with regard to their respective associations with other EBRBs.

In summary, the results of our study suggest that it is unlikely that time spent playing active video games substitutes other physical or sedentary activities. However, spending more time playing active video games seems to be associated with a small, but significant increase in TV/DVD time and intake of snacks. Caution is therefore warranted in using active video games in health promotion, as such an intervention may have unexpected side effects.

Acknowledgements

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Appendix 1

Overview of activities recalled in the 24 hours diary

Main activity as shown in diary[1]	**Question**	**Time frame**	**Activity category used for analyses (unit)**
1. Sleeping			
Bed time	What time did you go to bed?		NA
Rise time	What time did you get up?		NA
2. Video gaming			
Active video gaming	How long did you play active video games? ... hours and ... minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Active video gaming (Minutes/day)
Non-active video gaming	How long did you play non-active video games? ... hours and ... minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Non-active video gaming (Minutes/day)
3. Watching television or DVD	How long did you watch TV/ DVD? ... hours and ... minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Watching TV/DVD (Minutes/day)
4. Non-gaming PC use (surfing on the internet, watching YouTube movies, chatting etc)	How long did you use the computer? ... hours and ... minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Non-gaming PC use (Minutes/day)
5. Homework	How much time did you spend on doing your homework? ... hours and ... minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Non-screen sedentary activities (minutes per day)

Main activity as shown in diary	**Question**	**Time frame**	**Activity category used for analyses (unit)**
6. Social activities • telephone calling • texting • chilling/hanging out with friends • going out • shopping	How long did you engage in the following activity?[2] … hours and … minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	• <3 METS[3] -> non-screen sedentary activities • >3 METS[3] -> other physical activities
7. Other hobby's • Reading • Listen to music • Playing an instrument -> which instrument did you play? • Other sedentary activities (eg. board games, drawing, crafting, puzzling)	How long did you engage in the following activity?[2] … hours and … minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	• <3 METS[3] -> non-screen sedentary activities • >3 METS[3] -> other physical activities
8. Sports and active play • Soccer • Tennis • Swimming • Athletics • Hockey • Basketball • Martial arts (eg. judo, karate, (kick) boxing) • Horse riding • Gymnastics • Ice skating • Dancing (eg. Breakdance, salsa, ballroom dancing) • Fitness/aerobics • Skating • Running • Other, namely [OPEN answer]	How long did you engage in the following activity?[2] … hours and … minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Sport and active play (minutes/day)

Main activity as shown in diary	**Question**	**Time frame**	**Activity category used for analyses (unit)**
9. Walking and cycling • to school/work/ intern • to (sport)club, union, friends, shops • just for leisure (e.g. cross around with your bike, walking your dog)	How much time did you spend on the following activity?[2]? ... hours and ... minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Other physical activities
10. Other transportation Transportation by moped, car, public transportation (bus, train, metro, tram) • to school/work/ intern • to the shops • other...	How much time did you spend on the following activity?[2] ... hours and ... minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Non-screen sedentary activities (minutes/ day)
11. Household chores (e.g. cleaning up your room, doing the dishes, doing groceries, cooking)	How much time did you spend on the following activity?[2] ... hours and ... minutes	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Other physical activities (minutes/ day)
12. Work and internship • Work • Intern	How much time did you spend on the following activity?[2] ... hours and ... minutes How would you the rate the intensity of the physical activity that is required for your work/ intern? Light, moderate, vigorous	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	<3 METS[3] -> non-screen sedentary activities >3 METS[3] -> other physical activities

Main activity as shown in diary	Question	Time frame	Activity category used for analyses (unit)
Energy intake[4]			
Consumption of snacks	Number of servings (fried snacks, potato chips, candy bars) they consumed between the main meals in the past 24 hours.	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Consumption of snacks (servings/day)
Consumption of sugar-sweetened beverages	Sport and energy drinks, non-carbonated and carbonated soda, excluding fruit juices • Consumed glasses (200ml) • Consumed cans (330ml) • Consumed bottles (500ml).	1) 4 pm - bed time 2) Rise time - noon 3) Noon till 4 pm	Consumption of sugar-sweetened beverages (ml/day)

[1]The Previous Day Physical Activity Recall (PDPAR) [13], the Flemish Physical Activity Computer Questionnaires for adolescents [15] and the Multimedia Activity Recall for Children and Adolescents (MARCA) [16] provided input for the questions on activities.
[2]Time expenditure was asked for each selected activity (see bullets in column 'activity') separately.
[3]According to compendium of Ainsworth et al., 2000 [22]
[4]Questions on energy intake were based on validated questionnaires of van Assema et al. [14] and Van der Horst et al. [17]

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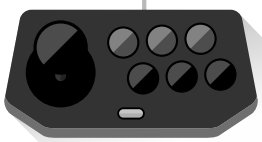
CHAPTER 4

Adolescents' Views on Active and Non-Active Video games: A Focus Group Study



Monique Simons
Emely de Vet
Sjoukje Hoornstra
Johannes Brug
Jaap Seidell
Mai Chinapaw

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Abstract

Objective

Active games require whole-body movement and may be an innovative tool to substitute sedentary pastime with more active time and may therefore contribute to adolescents' health. To inform strategies aimed at reducing sedentary behavior by replacing non-active with active gaming, perceptions and context of active and non-active gaming are explored.

Subjects and Methods

Six focus groups were conducted with adolescents 12–16 years old representing a range of education levels. A semi structured question route was used containing questions about perceptions and the context of gaming.

Results

The adolescents had positive attitudes toward active gaming, especially the social interactive aspect, which was greatly appreciated. A substantial number of adolescents enjoyed non-active games more than active ones, mainly because of better game controls and more diversity in non-active games. Active games were primarily played when there was a social gathering. Few game-related rules and restrictions at home were reported.

Conclusions

Given the positive attitudes of adolescents and the limited restrictions for gaming at home, active video games may potentially be used in a home setting as a tool to reduce sedentary behavior. However, to make active games as appealing as non-active games, attention should be paid to the quality, diversity, and sustainability of active games, as these aspects are currently inferior to those of traditional non-active games.

Introduction

Adolescence is characterized by a decrease in physical activity [1] while simultaneously many adolescents spend a considerable proportion of the day in sedentary activities [2]. Excessive time spent in sedentary behavior is associated with overweight [3–5], and reducing sedentary behavior is considered important for prevention of overweight [6;7].

Several studies have shown that gaming forms a significant portion of the sedentary pastimes of adolescents [2;8–10]. A new generation of video games, so-called active games, may transform this traditional sedentary behavior in a physically more active one. Active games require body movements beyond those required to operate traditional handheld controller video games (non-active games). Examples of active game applications or consoles are the Nintendo Wii™ (Nintendo, Kyoto, Japan), Xbox 360 Kinect™ (Microsoft, Redmond, WA), and PlayStation®Move (Sony, Tokyo, Japan). Energy expenditure while playing active video games is substantially higher than that during sedentary behavior and is comparable to light-to-moderate physical activity [11;12].

If traditional physically inactive video games (non-active games) could be replaced by active games, this could reduce sedentary pastime and increase physical activity. Enjoyment is known to be crucial for encouraging participation in an activity [13–15]. Therefore it is crucial that active games are considered at least equally appealing as non-active games. A qualitative study showed that 10–14-year-old children enjoyed playing active games [16]. However, studies also showed that children lost their interest in active games over time [17–19]. No research has been conducted to compare views on active games with views on non-active games, despite the fact that this is important information when aiming to replace non-active games with active games.

In order to inform strategies aimed at reducing sedentary behavior by replacing non-active with active gaming, the first step is to gain insights into the views on active and non-active gaming. Therefore, the current study explored the following: (1) Adolescents' reasons for playing active and non-active games (aspects liked/not liked, preference for active or non-active games, prerequisites for long-term engagement) and (2) the context of active and non-active gaming (when do you play, with whom, rules and restrictions at home).

Methods

Participants and design

Focus groups were conducted because of their effectiveness in gathering new insights into an unexplored field [20].

Spread over three secondary schools, three school classes from pre-vocational education (low-level educated), one school class from higher secondary education (high-level educated), and two classes from pre-university education (high-level educated) were invited to participate. In each class, a group of five to seven adolescents was selected for one focus group based on the following inclusion criteria: (1) 12–16 years old; (2) playing non-active games at least once a week; and (3) having played an active game at least once before. These criteria were chosen because we were most interested in opinions of non-active gamers, because eventually we are interested in promoting active game play among non-active gamers. Adolescents who intended to participate received a letter for their parents explaining the study and how, if applicable, they could object to their child's participation. None did so. In total, 37 adolescents (26 boys, 11 girls) participated in six focus groups. Table 1 shows the participants' characteristics.

Table 1: Participants characteristics

	n
Number of participants	37
Mean age (SD)	14.4 (1.2)
Gender	
• Male	26*
• Female	11
Educational level	
• Prevocational (lower educational level) (three focus groups)	18
• Higher secondary and pre-university (higher educational level) (three focus groups)	19
Ethnicity	
• Dutch origin	24
• Non-Dutch origin**	13
Gaming behaviour, hours per week (SD)	
• Non-active gaming	7.0 (6.3)
• Active gaming	0.7 (1.3)

*The higher number of boys compared with girls is in line with the known prevalence of gaming.
**Turkey, two; Morocco, one; Hong Kong, one; Iraq, two; Kurdistan, one; Belgium, one; Poland, one; Greece, one; Suriname, two; and France, one.

Procedures

Focus groups were conducted in June 2009 and carried out following the procedures proposed by Morgan and Krueger [21]. All six focus groups were audio-recorded and facilitated by two researchers. One interviewer conducted the actual interviews, and one assistant took notes. Focus groups were held during teaching hours at school and lasted 38–64 minutes. Before the start of each focus group, participants completed questions about their age, gender, ethnicity, and gaming behavior for descriptive purposes. After this, the terms "active" and "non-active" video games were explained: "Non-active video games are games in which players only have to use their fingers or hands," and "active video games are games that require movement of the body, more than only fingers and hands (e.g., Nintendo Wii)." Focus groups were conducted in a semi structured format; a schedule with two pre-identified themes and open-ended questions guided the discussions. The discussions started with the participants introducing themselves and naming their favorite video games, to make the adolescents feel more at ease. Afterward the adolescents received a game magazine as an incentive.

Interview topics

The interview topics were inspired by self-determination theory [22] and social cognitive theory [23]. These theories have been applied to explain health behaviors and specific types of gaming behavior [15;24]. Self-determination theory suggests that behavior that is performed as a result of intrinsic motivation (i.e., motivation that is driven by individual interest and enjoyment) and is likely to be maintained over time.14 Therefore questions relating to gaming motivation (e.g., enjoyment, fun, interest) were incorporated into the topic list. Social cognitive theory posits that people, environment, and behavior are constantly influencing each other [23]. In this light, the gaming context (the social context and the context in terms of game-related rules and restrictions from parents) was discussed. Table 2 presents the outline of the topic list.

Table 2. Topic list focus groups

Theme	Questions
1. Perceptions of active and non-active games	a. What is fun about playing non-active games? b. What do you think of active games? (aspects liked/not liked) c. Which kind do you like better: active or non-active games? d. What makes a video game attractive in the long term? e. Can you describe your ideal game?
2. Contexts of active and non-active gaming	a. When do you play video games? Is there a difference between active and non-active games? b. With whom do you play video games? Is there a difference between active and non-active games? c. Do your parents have any rules or restrictions for you regarding playing video games? Is there a difference between active and non-active games?

Data analysis

The audio-recorded focus groups were transcribed verbatim. Transcripts were coded and analyzed with Atlas.ti™ version 5.2 computer software (ATLAS.ti Scientific Software Development GmbH, Berlin, Germany) using the framework approach. The framework approach starts deductively from a preset theoretical background and objectives but also uses inductive analysis in order to reflect original discussions [25].

The first phase was getting familiar with the data, followed by assigning codes to the quotations (every quotation got a label, which describes its content; quotations with comparable content got the same label). Next, the codes were reassigned to larger families, and the families were rearranged into the two preset themes: Perceptions and context. Two researchers (M.S. and S.H.) conducted the coding and reassignment of the data independently. The differences in coding and interpretations were discussed and if necessary adapted until a consensus was reached. After coding analysis was performed, quotations were clustered, and the different views of the participants were compared. The results presented are analytical interpretations of themes and categories illustrated by representative quotations (see Table 3, Q1–Q42).

Focus groups were held until no significant new information was revealed. This point was defined by counting new codes per focus group transcript and calculating a percentage from the total number of codes that was generated from all interviews [26]. After the fifth focus group 95 percent of all codes were generated. During the sixth focus group no significant new information emerged so at that point we decided that there was no need for an additional focus group.

Results

Perceptions of active and non-active games

What is fun about playing non-active video games?

Elements that make video games fun that were brought forward were as follows: Genre; interesting and realistic storyline (Q1, Q2); competition; group play; feeling of mastery (Q3); challenge (Q4); doing things that are not possible in real life (Q5); and good-quality graphics, realistic graphics, and the feeling of really being in the game (Q6). Boys frequently mentioned that they liked violent video games (Q7). Girls often reported that they liked "life simulation games" (e.g., games in which they can babysit, cook, or dress hair).

What do you think of active video games (aspects liked/not liked)?

Aspects that adolescents liked about active gaming were as follows: Being physically active (Q8); interactivity (Q9); realistic movements; one-to-one translation of

their movements into the game; and the social aspect. Adolescents mentioned that they mostly enjoyed the one-to-one translation of their body movements into the gameplay and being challenged to make realistic body movements in order to play the game successfully. For example, they disliked needing to play a tennis game by making small wrist movements instead of a realistic arm swing. Adolescents particularly liked the suitability of active games for playing with other people. They played active games less seriously than non-active games; they liked to laugh with and at each other while playing active games.

Aspects that adolescents did not like about active gaming were as follows: Failure of technique (Q10); no one-to-one translation of their movements into the games (Q11); expensive accessories; injuries/accidents; and solo play. The main complaint regarding technical failures was that the sensor or controller in active games was not responding properly to their actions as it does in non-active games (Q12). Some adolescents in the higher educational level group expressed that it was actually "kind of stupid" to take part in a sport in front of a screen if the sport can also be practiced outside in real life, in particular when expensive accessories are necessary for playing the game. In the lower educational level group strains or injuries (Q13) and accidents that can occur during active video gaming (Q14) were discussed.

Which kind do you like better: Active or non-active games?

Some adolescents (mostly girls) said that they preferred active games over non-active games, but more often a preference for non-active games was mentioned. However, when in the company of their friends, many adolescents preferred active games above non-active games (Q15). The reasons for preferring non-active games over active games appeared to be mostly based on the lower quality of active games in terms of the graphics, storyline, diversity of games (Q16), controls, and technique. Some of the participants believed that the quality of active games will improve over time and that they will become even more fun than non-active games (Q17).

What makes a videogame attractive in the long term?

An aspect of influence on attractiveness in the long term was the amount of puzzles and missions that be solved and completed in a game. This aspect is mainly relevant for the action and adventure game genres. The adolescents indicated that action and adventure games are no longer interesting when all the puzzles are solved and all the missions are completed. It can take adolescents from 10 minutes up to 1 year to finish an action/adventure game. This depends mostly on the quality of the game; higher-quality games (e.g., "Grand Theft Auto" [Rockstar Games, New York, NY] [Q18]), with extensive worlds and many missions to complete, will last longer and can even be played again after finishing. Also, sports (e.g., "FIFA Soccer" [Electronic Arts, Redwood City, CA] [Q19]) and simulation video games (e.g., "The Sims" [Electronic Arts]) were mentioned

as video games that retain their attractiveness in the long term. In addition to genre, the following features were also mentioned as being of importance for the attractiveness of the game in the long term: Online modus; multiplayer options; and the opportunity to improve oneself (Q20).

Some adolescents indicated that active games became boring sooner than non-active games. They initially liked playing active games but quickly got bored and hardly ever played them anymore. One adolescent mentioned that active games remained more enjoyable in the long term compared with non-active games because often an active game never ends (Q21) and you can keep on getting better at it (Q22).

Can you describe your ideal videogame?

Many adolescents described their ideal videogame as a game in which they were fully transported into a virtual world. They talked about a helmet that would bring them into a three-dimensional and realistic virtual world (Q23, Q24). The ideal game control was by means of their own body movements (if it worked properly [Q25]), with an exact representation of their actions in the game (e.g., if they ran, they also wanted to see that translated into the game immediately) (Q26, Q27). However, there were also adolescents who preferred to use a traditional joystick or a handheld controller with buttons.

Contexts of active and non-active gaming

When do you play video games? Is there a difference between active and non-active games?

The most frequently mentioned context was gaming when the adolescents felt like it, when they had nothing else to do (Q28), or when they felt bored, as it is "an easy solution to boredom" (Q29). The adolescents mostly played video games in the afternoons, after finishing school or homework, or in the evenings. Some adolescents said that they were more likely to play video games in bad weather and that they preferred going outside in good weather (Q30, Q31).

For playing active games, the contexts were generally similar, except for the fact that adolescents mentioned that they played active games whenever they saw the console and were reminded of the games. It was mentioned that they played active video games more often in winter than in summer because they did not like to play active video games when it was hot (Q32). Another adolescent mentioned to play active video games in order to warm up when it was cold.

With whom do you play video games? Is there a difference between active and non-active games?

Many adolescents liked to play video games with their friends. In particular, active games were played with friends or when there was a social gathering or party (Q33). As such, active games were called "party games" (Q34). Some adolescents mentioned

that it was not "cool" to play active games on your own (Q35). Friends were not always around, and so then they would play games on their own (mostly non-active games) (Q36). In addition to their friends, siblings and parents were also mentioned as gaming partners. Some adolescents mentioned that they did not enjoy gaming with their parents or siblings because they were not good at it. When parents were mentioned as gaming partners, it was mostly for active video games and not for non-active video games (Q37).

Do your parents have any rules or restrictions for you regarding playing video games? Is there a difference between active and non-active games?

Almost none of the adolescents mentioned that their parents had game-related rules or restrictions for them. Most adolescents indicated that when they were younger, there were more rules and restrictions regarding gaming (Q38). If parents did apply rules, then it was a maximum amount of gaming time (Q39), a rule against gaming late in the evening, or rules related to schoolwork. Some adolescents expressed that they had to share the game console with their siblings and that their parents have rules to make sure that the gaming time is spread evenly among all of the siblings (Q40).

When asked about rules for active games, some adolescents thought that their parents allowed them to play for longer with active games compared with non-active games (Q41, Q42).

Table 3. Selection of illustrative quotations per topic

Theme and question	Participant quotation
1. Perceptions of active and non-active games	
a. What is fun about playing non-active games?	1. "Not some story about somebody dying and everyone throwing a party and then, uhm, (…) gets mad, yeah, some story like that." [Lower educational level, boy] 2. "It's like, uhm, in some games you just, uhm, have a rocket or you drive a tank over a tree and it doesn't break down, or you drive right through it." [Lower educational level, boy] 3. "It gives you a feeling kinda like: 'Wow! I did it'." [Higher educational level, boy] 4. "And a challenge to finish the game". [Higher educational level, boy] 5. "It's like you can do things that you wouldn't normally be able to do, you know." [Higher educational level, boy] 6. "It is just fun to get in the game …" [Low educated, girl] 7. "Shooting everybody, ha ha [laughs]. That's what I like." [Lower educational level, boy]
b. What do you think of active games? (aspects liked/not liked)	8. "You have to be active, you know, you don't just sit on the sofa or whatever. You actually have to do something." [Lower educational level, boy] 9. "It's interactive. That's really fun. That you can control it yourself just by moving. You know, you can put your own body movements into the game, you know." [Higher educational level, boy] 10. "It's like with EyeToy [an active game] it doesn't always work right. And then, uhm, and then if something goes wrong and then you, like, have to do something all over again. And that really sucks, you know?" [Higher educational level, boy] 11. "The game character is spinning around really fast and he is like waving his sword around with both hands ….but you only have to make a small wrist movement to make him do that…." [Higher educational level, boy] 12. "In an active game it doesn't always responds and a non-active game just responds. It just works if you push the button". [Higher educational level, boy] 13. "Your arm can start to hurt when playing on the Wii and smashing like this [makes arm gesture] the whole time". [Low educated, boy] 14. I once played on the Wii and then I got a wound… I hit my arm against the lamp". [Low educated, boy]

Theme and question	Participant quotation
c. Which kind do you like better: active or non-active games?	15. "Usually if your friends are over, it is more fun to play active games..." [Higher educational level, boy] 16. "As for non-active games you've just got more, more fun games. The Wii is just more of the same." [Lower educational level, boy] 17. "If they work out the game plan in a good way and the controls were better, then it [active video games] would probably be more fun, because you'd be more active. But now I still think the non-active games [*are more fun*]." [Higher educational level, boy]
d. What makes a video game attractive on the long term?	18. "*[GTA]* it doesn't matter if the story is over, ... you can still mess around in the virtual world where the story takes place" [Higher educational level, boy]. 19. "And Fifa, because there are always new actions possible, you know, you can always shoot in different ways and eh ..... a lot of options for shooting and that makes it fun...."[Lower educational level, boy]. 20. "But that [Guitar Hero] is just a game, at which you can get better and better at it; four levels you know like first there's easy, then hard and then expert...and you keep going and it's always fun...hard to believe but it's the truth..." [Higher educational level, boy]. 21. "You just can keep on playing those games [*active games*] ..... You can't end those games" [Higher educational level, boy]. 22. "You can improve yourself" [Higher educational level, girl].

Theme and question	Participant quotation
e. Can you describe your ideal video game?	23. "My ideal game is one just like D. [other participant] explained with a helmet and that you are really transported into the game, that would be awesome. I really would pay 500 Euro's or something for that kind of game.....That it is super real and that the helmet makes a connection with your brains or something...."" [Higher educational level, boy]. 24. "Yes, you can sit with your head in a helmet.....and then you have a car and a steering wheel and then you can see everything in 3-D and everything is coming right to you. And you are totally disconnected from the space around you. You are really in the game." [Lower educational level, girl]. 25. "I think that would be an active game, but then everything should really work well." [Higher educational level, boy]. 26. "That if you trip, the avatar also trips .... That when there is a real weapon, that you hold a fake weapon and you shoot like this...."[Lower educational level, boy]. 27. "Fifastreet with body movements....that would be really cool..... and that you do your own tricks, that would be really fun." [Lower educational level, boy].
2. Context of active and non-active gaming	
a. When do you play video games? Is there a difference for active and non-active games?	28. "During summer break you have other things to do." [Lower educational level, boy] "An easy solution to boredom..." [Higher educational level, boy]. 29. In summer when its holiday time, you'd rather go swimming for example than sitting behind the computer for the whole day." [Higher educational level, boy]. 30. "When the weather is nice, you usually go outside." [Higher educational level, boy]. 31. "If it is already really warm and you would have to be active.... ..."[Lower educational level, girl].

Theme and question	Participant quotation
b. With whom do you play video games? Is there a difference for active and non-active games?	33. "If there are a bunch of people around you're not going to go sit by yourself and play a shooter video game." [Higher educational level, boy] 34. "Active games are generally 'party games'. Ehh, that's fun if you are with a group of people. If I play Wii Sports, it's usually because we're throwing a party... a barbeque or something, with a bunch of people. Everyone plays, it's just a party game." [Higher educational level, boy] 35. "But another thing is that those active games on the Wii and whatever usually aren't too much fun on your own. I think it's a lot more fun if a bunch of people play. But then if you're alone, it's just, it's just... if you play Wii Sports on your own then you're really just a bit of a loser". [Higher educational level, boy] 36. "But it depends, because sometimes, uhm, you know, my friends can't come over and then I play on my own." [Lower educational level, girl] 37. "Hahaha [laughs] my parents also just like the Wii. Hahaha [laughs] my mother also played it once with her friend" [Higher educational level, girl]
c. Do your parents have any rules or restrictions for you regarding playing video games? Is there a difference between active and non-active games?	38. "We used to have rules but they became less and less strict ... so nowadays I can game basically whenever I want ... but sometimes it just is enough you know..."[Higher educational level, boy] 39. "Two hours, but I don't know, I usually sit for five hours or something" [Lower educational level, boy] 40. "1.5 hour or something and then it is my brother's turn again." [Lower educational level, girl] 41. "If I play active games with friends, it is not like they say 'now you have to stop playing', because parents often say that you should do something with friends and then you are doing something active with friends and although it is still gaming, the rules just disappear." [Higher educational level, boy] 42. "I am allowed to play active games more often than non-active games, because it is good for you" [Lower educational level, girl]

Discussion

The current study aimed at gaining insights into (1) adolescents' perceptions of active and non-active games and (2) the contexts of playing active and non-active games.

Almost all adolescents said they enjoyed playing active video games, although a substantial number of adolescents expressed that they enjoyed non-active games more than active ones. According to self-determination theory, enjoyment is an important aspect of behavioral choices and the decision to continue a specific behavior [14]. Therefore, in order to replace time spent on non-active games by time spent on active games, it seems important that active games become as enjoyable as, or even more enjoyable than, non-active games. When we asked why the adolescents liked active games, answers were merely related to physical activity and the interactive aspect in the game. This suggests that action is a real part of the gameplay for active games. Reasons for liking non-active games more were related to the better quality of graphics and storyline, more diversity in non-active games, and good working technology and controllers. It is important that ultimately the best of both worlds are combined: High quality in storyline and gameplay and fun body movements. If these two aspects are integrated in future active games, it seems likely that popularity of active games will increase, which could lead to more adolescents playing active games and being physically active while gaming. So if active games are going to be used as tool for increasing physical activity in adolescents, it is important to improve gameplay of active games. Specific recommendations for active games that came forward from the focus groups were as follows: More precise translation of body movements into gameplay; better quality graphics; more realistic graphics; more variety of games; better working controls; and using three-dimensional images. The focus groups did not provide clear examples of active games that are better appreciated. Future studies should focus on which active games are better appreciated and evaluate why that is. If active games are to be used in interventions aiming at reducing sedentary behavior and overweight in adolescents, it is important that active games remain attractive and fun in the long run. The current study shows that this is an important aspect to consider because adolescents often mentioned that active games get boring quickly, whereas non-active games do seem to be able to maintain interest of adolescents in the long term. Active games seem to lack the thrill that the higher-quality non-active games can deliver. Important elements for increasing sustainability in gameplay were, for example, high-quality story and online play possibilities. The active games that the adolescents were exposed to (mostly Nintendo Wii games) were often of lower quality with simplistic virtual worlds, little story, and fewer options for online play compared with non-active games. Although more research is still needed on how the long-term use of active video games can be stimulated, these elements should be taken into account in future active games design and when selecting active games for implementation. The results on the second theme—gaming context—showed that active games were primarily played when other people were around. Active

games were considered more social than non-active games. As group play can encourage participation in active games [17;24], the social nature of active games is an aspect that should be capitalized on. For example, increasing options for online play in active games could provide an extra opportunity for group play.

Although other studies showed that parents appeared to play a role in terms of applying game-related rules and restrictions [2;27], adolescents in the current study indicated that their parents applied few rules and restrictions regarding gaming. A small supplementary study, involving 10 interviews with adolescents' parents (authors' unpublished data), confirmed this and suggested a positive attitude from the parents toward active gaming, which opens up an opportunity for implementing active games in the home setting.

The current study was the first to explore perceptions of active gaming in 12–16-year-old children, but similar studies have been conducted among 8–12-year-old* and 10–14-year-old children and their parents [16] that also showed support for active gaming from both parents and children. The 8–12-year-old children even preferred active games above non-active games.* The 10–14-year-old children in the study of Dixon et al. [16] mentioned that playing active games would be less popular when they reached high school because it would not be seen as "cool." It seems that adolescents have higher demands for game quality that should be taken into account when implementing active gaming for adolescents, together with the "coolness" factor.

Limitations of the study are that, although effort was made to include gaming adolescents from a range of ethnic backgrounds and educational levels, reported findings are descriptive and cannot be generalized. Quantitative studies should further evaluate the factors identified in representative samples. Furthermore, most adolescents in our study population played active games on the Wii, as this was the most widely available console at the time of study, so most quotes are concerning Wii games. Very recently, also other active game consoles, like Xbox 360 Kinect and PlayStationMove, have been introduced. These active game consoles use different technology than Nintendo Wii, so not all results are translatable to all active game systems.

In conclusion, the positive attitudes shown by adolescents and the lack of major restrictions for gaming at home suggest that active video games may potentially be used in a home setting as a tool to reduce sedentary behavior. However, to make active games as appealing as non-active games, attention should be paid to quality, diversity, and sustainability of active games as they are currently perceived to be inferior to traditional non-active games.

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Footnote

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CHAPTER 5

Personal, Social, and Game-Related Correlates of Active and Non-Active Video Gaming Among Dutch Gaming Adolescents: Survey-Based Multivariable, Multilevel Logistic Regression Analyses

5

Monique Simons
Emely de Vet
Mai Chinapaw
Michiel de Boer
Jaap Seidell
Johannes Brug

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Abstract

Background

Playing video games contributes substantially to sedentary behavior in youth. A new generation of video games—active games—seems to be a promising alternative to sedentary games to promote physical activity and reduce sedentary behavior. At this time, little is known about correlates of active and non-active gaming among adolescents.

Objective

The objective of this study was to examine potential personal, social, and game-related correlates of both active and non-active gaming in adolescents.

Methods

A survey assessing game behavior and potential personal, social, and game-related correlates was conducted among adolescents (12-16 years, N=353) recruited via schools. Multivariable, multilevel logistic regression analyses, adjusted for demographics (age, sex and educational level of adolescents), were conducted to examine personal, social, and game-related correlates of active gaming ≥1 hour per week (h/wk) and non-active gaming >7 h/wk.

Results

Active gaming ≥1 h/wk was significantly associated with a more positive attitude toward active gaming (OR 5.3, CI 2.4-11.8; *P*<.001), a less positive attitude toward non-active games (OR 0.30, CI 0.1-0.6; *P*=.002), a higher score on habit strength regarding gaming (OR 1.9, CI 1.2-3.2; *P*=.008) and having brothers/sisters (OR 6.7, CI 2.6-17.1; *P*<.001) and friends (OR 3.4, CI 1.4-8.4; *P*=.009) who spend more time on active gaming and a little bit lower score on game engagement (OR 0.95, CI 0.91-0.997; *P*=.04). Non-active gaming >7 h/wk was significantly associated with a more positive attitude toward non-active gaming (OR 2.6, CI 1.1-6.3; *P*=.035), a stronger habit regarding gaming (OR 3.0, CI 1.7-5.3; *P*<.001), having friends who spend more time on non-active gaming (OR 3.3, CI 1.46-7.53; *P*=.004), and a more positive image of a non-active gamer (OR 2.0, CI 1.07–3.75; *P*=.03).

Conclusions

Various factors were significantly associated with active gaming ≥1 h/wk and non-active gaming >7 h/wk. Active gaming is most strongly (negatively) associated with attitude with respect to non-active games, followed by observed active game behavior of brothers and sisters and attitude with respect to active gaming (positive associations). On the other hand, non-active gaming is most strongly associated with observed non-active game behavior of friends, habit strength regarding gaming and attitude toward non-active gaming (positive associations). Habit strength was a correlate of both active and non-active gaming, indicating that both types of gaming are habitual behaviors.

Although these results should be interpreted with caution because of the limitations of the study, they do provide preliminary insights into potential correlates of active and non-active gaming that can be used for further research as well as preliminary direction for the development of effective intervention strategies for replacing non-active gaming by active gaming among adolescents.

Introduction

The prevalence of overweight and obesity in Dutch youth has increased in recent decades [1]. Overweight and obesity represent major public health problems [2;3]. Promoting physical activity (PA) and reducing sedentary behaviors are important targets for the prevention of overweight in youth [4;5]. Playing video games contributes significantly and substantially to sedentary behavior in youth [6-8]. For example, in the Netherlands, 95% of adolescent boys and 85% of adolescent girls play video games for an average of 10 and 4 hours per week (h/wk), respectively [8]. Correlates of playing video games identified previously include gender, age, ethnic background, and parents' educational level [6;7;9;10]. One of the most consistent findings in these studies is the difference between boys and girls: boys generally spend more time gaming than do girls [6;7-9]. With respect to age, US children aged 11-14 years appear to play more than 8- to 10-year-old children. Regarding ethnic background, Hispanic and African American youth (8-18 years old) spend more time playing video games than white youth [7]. Furthermore, a study among 10- to 11-year-old Flemish children and their parents [9] and a study among 4- to 18-year-old Dutch children and their parents [10] showed that compared to children of higher-educated parents, children of parents with low or medium education levels spend more time playing video games.

A new generation of video games—active games—seems a promising alternative to sedentary games in promoting PA and reducing sedentary behaviors in youth [11-13]. Active games require movement of the body, more than only fingers and hands (eg, Nintendo Wii, PlayStation Move) [14]. Several studies have shown that active games involve light to moderate intensity physical activity (2-6 metabolic equivalents) [11;15], and pilot studies suggest that active gaming is associated with more PA and less sedentary time [13;16]. A large 6-month study showed that playing active games was associated with lower body mass index in children [17]. Furthermore, a number of studies have shown that a substantial proportion of adolescents play active games [17-19]. In the Netherlands, 43% of adolescents indicated that they play active games [19]. In Canada, this percentage was 25% [18].

To our knowledge, little attention has been paid to the correlates and determinants of active gaming. O'Loughlin explored potential socio-demographic, lifestyle, psychosocial, weight-related, and mental health correlates in Canadian adolescents. They showed that active gamers were more likely to be female, play non-active video games, watch ≥2 hours of television per day, be concerned about weight and be nonsmokers compared to adolescents who did not play active games [18]. A Dutch study comparing regular active gamers (≥1 h/wk) with non-regular active gamers (<1 h/wk) showed that regular active gamers (≥1 h/wk) were slightly but significantly younger (13.5 vs 14.1 years old) but did not differ with respect to gender, education level (of adolescent and parent), ethnicity, or sedentary screen time (TV/DVD and computer time) [20].

In a previous study, we examined and compared demographic correlates of active gaming and non-active gaming simultaneously in Dutch adolescents [19]. Irrespective of age, adolescents attending a lower educational level of secondary school were more likely to play active games ≥1 h/wk than adolescents attending higher educational levels. For non-active gaming, gender and age were correlates, with boys and older adolescents being more likely to play non-active games >7 h/wk than girls or younger adolescents [19]. There are no generally accepted cutoff values for active and non-active gaming. Therefore we based the 1 h/wk cutoff value on calculations in adults (because child-specific ones were not available at that time) that demonstrated that excessive weight gain can be prevented if energy balance is affected by 70 kcal/wk [21]. This corresponds with 1 hour of active gaming [15]. Second, 1 h/wk seems feasible to incorporate into intervention programs. Studies show that gaming adolescents spent, on average, 4-10 h/wk playing non-active games [8;19]. Replacing all non-active game time does not seems realistic, but asking to replace 1 hour out of 4-10 hours seems doable. Furthermore, only 28% of the active gaming adolescents played for ≥1 h/wk, indicating there is still room for improvement [19]. For non-active gaming, we used 1 hour per day (7 h/wk) as the cutoff value because this represents half of the 2 hours of maximum total screen time recommended for adolescents [22] and is the same cutoff value used by Allahverdipour et al in their study on non-active gaming [23].

In summary, previous studies tended to focus on the prevalence and on demographic characteristics of (active) gamers and on either playing traditional non-active games or active games rather than both types of gaming simultaneously. The latter is necessary to examine differences in the correlates of active gaming and non-active gaming. Moreover, no attention has been paid to potential personal, social, or game-related correlates of playing both active and non-active games. More specifically, the focus has been on who is playing active and non-active games rather than on why adolescents may play these games. Understanding why people play active and non-active games could provide directions to future intervention strategies attempting to substitute active game play for non-active game play. Therefore, the current study focused on potential personal, social, and game-related correlates of active as well as non-active gaming.

The selection of potential correlates for the current study was based on the findings of a focus group study conducted with adolescents about active and non-active gaming, which showed image, ease of use, and playing with others are important factors in gaming for adolescents [14]. Furthermore, the correlates were based on theories that have been applied to sedentary behavior, physical activity, or specific types of gaming [24-26]; Theory of Planned Behavior (TPB; attitude, descriptive norm) [27], Self-Determination Theory (SDT; autonomous motivation, game engagement) [28], Technology Acceptance Model (TAM; ease of use, competence) [29], and Habit Theory (habit) [30]. This has necessarily led to an extensive set of potential correlates tested, which we found appropriate given the fact that this is a first exploratory study of such

correlates. The results can and will be used for more targeted exploration of correlates and potential determinants in future research. The correlates were structured according to three categories. First, personal correlates were distinguished, which refer to individual psychological factors such as attitude toward playing active and non-active games, autonomous motivation for playing video games, self-perceived gaming competence, habit regarding playing video games, and attitude toward physical activity. Second, we distinguished factors that relate to the social aspects of gaming (eg, descriptive norm) and social images of active and non-active gamers, referring to these as social correlates. Third, and finally, factors that are related to the video games were assessed, namely, perceived ease of use of playing active and non-active games, game engagement, and number of active and non-active games in possession.

The current study aimed to (1) examine potential personal, social, and game-related correlates of active gaming (≥1 h/wk) in adolescents; (2) examine potential personal, social, and game-related correlates of non-active gaming (>7 h/wk) in adolescents; and (3) compare the correlates of active gaming (≥1 h/wk) with those of non-active gaming (>7 h/wk).

Methods

Design and Procedure

The current study makes use of data gathered in a larger prospective study on video games among adolescents and their parents (not published yet). The present study reports cross-sectional data from the first questionnaire completed by adolescents. The questionnaire was administered in the classroom under the supervision of the researcher and/or a teacher. On the day of the first survey, a researcher explained the goals and procedures of the study in the classroom. The researcher asked adolescents in a school class session whether they played video games (active and/or non-active games) at least once a week. Those who answered "yes" (further referred to as "gaming adolescents") and were willing to participate received the "gaming questionnaire", containing questions about gaming characteristics and demographics. The adolescents who did not play video games received a "non-gamers questionnaire", consisting of questions about demographics. The adolescents received an information letter for their parents with a passive consent procedure indicating that parents could object to the study participation of their child. In such cases, the questionnaire of the corresponding child was destroyed. Among adolescents who completed the entire study, 2 MP3 players, 6 gift vouchers of €10 for video games, and 6 gift vouchers worth €25 for video games were raffled as an incentive.

Participants

The Dutch secondary school system consists of three levels of education: (1) pre-vocational, (2) higher continued education, and (3) pre-university. The participants were recruited from 5 secondary schools in the Netherlands, covering all educational levels, whereby a maximum of 4 classes per school were included. The aim was to establish a representative sample of enrolled schools covering a wide range of socioeconomic, ethnic, and geographic characteristics, as described in Simons et al. [19]. Therefore, the approached schools varied with respect to location (urban/nonurban) and educational level. In total, 459 students from 18 classes were invited to participate. The current study focused on the gaming adolescents only, resulting in 357 (77.7%) eligible students. Three parents objected to their child's participation, and 1 student was dismissed from class because of misbehavior and not filling out the questionnaires seriously. The data from these students were therefore excluded, resulting in approved responses from 353 adolescents.

The Central Committee on Research Involving Human Subjects in the Netherlands provided an exemption for this study to seek formal approval from the Medical Ethics Committee.

Measures

Demographic Factors

Questions regarding birth date (for calculating age), gender, and educational level (pre-vocational, higher education, pre-university) were included in the questionnaire. Educational level was dichotomized into low level (pre-vocational) and high level (higher education and pre-university).

Outcome Measures

We focused on 2 outcome measures: (1) time spent active gaming, and (2) time spent non-active gaming. To assess time spent active and non-active gaming, questions about frequency and duration were formulated based on existing and validated questionnaires for adolescents [31;32] for school and weekend days separately. Adolescents could indicate duration by selecting 1 of 4 categories (<30 minutes, 30 to <60 minutes, 1-2 hours, and >2 hours). The terms active and non-active games were explained as follows: non-active games are games in which players only have to use their fingers or hands, and active games are games that require movement of the body, more than only fingers and hands (eg, Nintendo Wii, PlayStation Move, Microsoft Kinect).

Time spent active gaming was dichotomized into durations lasting <1 h/wk and ≥1 h/wk [19;20]. Because there is no general accepted cutoff value for active gaming, this cutoff value was based on calculations in adults demonstrating that excessive weight gain can be prevented if energy balance is affected by 70 kcal/wk [21]. Based on calculations of energy expenditure during active video game play [15], substituting sedentary

activities with playing active games for 1 h/wk corresponds to an additional 70 kcal of energy expenditure each week and may thus prevent excessive weight gain [20]. Second, 1 h/wk seems feasible to incorporate into intervention programs as described in the introduction.

Time spent non-active gaming was dichotomized into durations lasting ≤7 h/wk and durations lasting >7 h/wk. There is no general accepted cutoff value for non-active gaming. We used 1 hour per day as the cutoff value because this represents half of the 2 hours of maximum total screen time recommended for adolescents [22] and is the same cutoff value used by Allahverdipour et al. in their study on non-active gaming [23].

Attitude, descriptive norm, image, perceived ease of use, and number of games in possession were assessed with respect to active and non-active gaming separately. Autonomous motivation, self-perceived gaming competence, habit, and game engagement were assessed with respect to gaming in general.

Personal Correlates

Attitude Toward Playing Active/Non-Active Games

Attitude (based on TPB [27]) was assessed by asking respondents to evaluate playing active/non-active games on six 5-point bipolar scales, based on a manual for constructing questionnaires based on TPB [33] (eg, "I think playing active/non-active games is": "very stupid" [score of 1] to "very enjoyable" [score of 5]). The 6 items were combined into one construct by averaging the scores (attitude active gaming, Cronbach alpha=0.77; attitude non-active gaming, Cronbach alpha=0.73).

Autonomous Motivation for Playing Video Games

Type of motivation was deduced from the SDT [24;28] and assessed using a modified version of the Perceived Locus of Causality scale [34]. To prevent the questionnaire from becoming too lengthy, we used a modified version by selecting the 2 most relevant items with the highest factor loadings for each type of motivation [35]. Four types of motivation were assessed: (1) external regulation, (2) interjected regulation, (3) identified regulation, and (4) intrinsic regulation [34]. The respondents were asked to indicate on a 5-point scale (totally disagree [score of 1] to- totally agree [score of 5]) whether they agreed on statements starting with "I play video games …" for example, for interjected regulation, "because I want my friends to think that I am good in playing video games"; for identified regulation, "because I want to improve in playing video games"; and for intrinsic regulation, "because playing video games is fun." The 10 items were combined into a Relative Autonomy Index (RAI) by weighting the external subscale –2, the interjected subscale –1, the identified subscale +1, and the intrinsic subscale +2. Amotivation was not considered in the formulation of the RAI [36]. The minimum score for the RAI is –30, and the maximum score is +30. Higher positive scores for the RAI indicate more autonomous motivation, whereas lower negative scores indicate less autonomous motivation.

Self-Perceived Gaming Competence

Perceived competence is based on SDT, which contends that competence is one of the basic needs that drive behavior [24]. Self-perceived gaming competence was measured using the 3 most relevant items of the validated Intrinsic Motivation Inventory (originally consisting of 6 items) [37]. Respondents had to indicate on a 5-point scale ([score of 1] totally disagree to [score of 5] totally agree) whether they agreed with the following statements: "I believe I am good at playing video games", "I think I am better at playing video games than other people my age and gender", and "I am generally happy with my gaming performance." The statements were combined into one construct (Cronbach alpha, 0.84). The Cronbach alpha in the current study was 0.84, which is comparable to the value of 0.81 that Markland and Hardy [38] observed for the competence subscale when they assessed the factorial and construct validity of the Intrinsic Motivation Inventory.

Habit Regarding Playing Video Games

To assess habit strength with respect to playing video games, we used 4 items from the 12-item Self-Reported Habit Index [30]. Four items that reflected 2 important aspects of habits were selected: automaticity (the extent to which particular behaviors are executed efficiently, outside control and awareness) and identity (the extent to which the behavior is part of everyday life and reflects a sense of personal style). The following items were included in the current study regarding playing video games ("Playing video games is something"): "…I do automatically" (automaticity), "…I start doing before I realize I'm doing it" (automaticity), "that is typically me" (identity), and "that belongs to my daily routine" (identity). Respondents were asked to indicate on a 5-point scale (totally disagree [score of 1] to totally agree [score of 5]) whether they agreed with the items. The reduced scale demonstrated good internal consistency in the current study (Cronbach alpha, 0.81).

Attitude Toward Physical Activity

Attitude toward physical activity was measured by asking respondents to evaluate physical activity on two 5-point bipolar scales, based on the manual for TBP questionnaires [33] ("Do you think it is fun or stupid to increase your physical activity behavior (very stupid [score of 1] to a lot of fun [score of 5])" and "Do you think it is good or bad to increase your physical activity behavior?" (very bad [score of 1] to very good [score of 5]). These 2 items were combined into one construct (Cronbach alpha, 0.76).

Social Correlates

Descriptive Norm Active and Non-Active Gaming

Descriptive norm (based on TPB [27]) was assessed on a scale from 1 (very little time) to 5 (very long time) with the following items, based on the TBP manual [33]: "Do most of your friends spend a lot of or little time playing active/non-active games?" and "Do your brothers or sisters spend a lot of or little time playing active/non-active games?"

The items were dichotomized into low (score 1-3) and high descriptive norms (score 4-5) for brothers/sisters and friends separately.

Image Regarding Active Gamers and Non-Active Gamers

Image as a potential correlate for gaming arose from focus groups held with adolescents about active and non-active gaming [14]. Social image or prototype is also a construct belonging to the Prototype Willingness model [39] and denotes the image that an adolescent associates with a behavior or the perceptions of the type of person who performs the behavior [39]. The Prototype Willingness model was originally developed to explain health risk behaviors (eg, drinking and smoking) in adolescents and young adults, and studies have shown that the images adolescents hold of peers who engage in risk behaviors are associated with adolescents' willingness to engage in risk behaviors when the opportunity arises [40;41]. To the best of our knowledge, the Prototype Willingness model has not yet been applied to gaming behavior. To assess the image of active and non-active gamers, respondents were asked to indicate what they thought of "an active/non-active gamer" using 6 characteristics. Respondents had to indicate on a 5-point scale ([score of 1] totally disagree to [score of 5] totally agree) whether they agreed with the following statements: "I think an active/non-active gamer is (1) unsportsmanlike, (2) cool, (3) childish, (4) companionable, (5) boring, or (6) attractive. Negative characteristics (unsportsmanlike, childish, and boring) were reversed, and statements were then combined into one construct for active gamers (Cronbach alpha, 0.62) and one construct for non-active gamers (Cronbach alpha, 0.77).

Game-Related Correlates

Perceived Ease of Use of Playing Active/Non-Active Games

Perceived ease of use is a construct deduced from the TAM and measures the extent to which people believe playing active/non-active games is effortless. To assess the perceived ease of use of playing active and non-active games, 2 questions were asked for active and non-active games separately: (1) "It is easy for me to learn how active/non-active games work", and (2) "Playing active/non-active games is easy for me." Respondents had to indicate on a 5-point scale ([score of 1] totally disagree to [score of 5] totally agree) whether they agreed. The 2 items were derived from Hsu and Lu [29] and were based on a validated questionnaire developed by Davis [42]. The 2 items were combined into one construct for non-active games (Cronbach alpha, 0.78) and one for active games (Cronbach alpha, 0.88).

Game Engagement

Game engagement is a generic indicator of game involvement that consists of the categories absorption, flow, presence, and immersion. Engagement was measured by means of the Game Engagement Questionnaire (GEQ) [43], which was developed to measure the potential of an individual to become engaged in video games. The GEQ consists of 19 items (eg, "If I play video games, I lose track of time", "If I play video games, I do not hear if someone is talking to me", "If I play video games, the game feels

real"). Respondents had to answer on a 3-point scale (no [score of 1], a little [score of 2], yes [score of 3]), and the scores were summed to yield a cumulative score. The Cronbach alpha in the current study was 0.91, which is comparable to the value of 0.85 observed by Brockmeyer et al when developing the scale [43].

Number of Active and Non-Active Games in Possession

Respondents were asked to indicate how many active and non-active games they had in their household.

Analyses

Of the 353 adolescents, 44 had missing values for one of the dependent variables (time spent active/non-active gaming), and another 59 adolescents had missing values for one of the potential correlates, resulting in 250 (80.9%) adolescents with complete data. We therefore decided to impute data using chained imputations [44] with an imputation model consisting of all the potential predictors, the dependent variables, and 6 other variables that we thought were related to missingness. These 6 variables were (1) spending a lot or a little time on playing active games (a little [score of 1] to a lot [score of 5]), (2) spending a lot or a little time on playing non-active games (a little [score of 1] to a lot [score of 5]), (3) playing active games in comparison with others (much less [score of 1] to much more [score of 5], (4) playing non-active games in comparison with others (much less [score of 1] to much more [score of 5]), (5) attitude toward spending more time on active gaming (scale 1-5), (6) attitude toward spending less time on non-active gaming (scale 1-5). Trace plots of means and standard deviations of imputed variables were checked for convergence. It was found that results were stable after 50 imputations, which was used in the final analyses.

Based on these 50 imputed databases, first descriptive analyses were performed on demographics to describe the study population and to explore personal, social, and game-related factors among gaming adolescents. Furthermore, to examine potential personal and game-related correlates of active ≥1 h/wk and non-active gaming >7 h/wk, 2 multilevel logistic regressions were performed, with all variables entered simultaneously. Variables entered in the model included all 17 potential correlates and the demographics (age, sex, and educational level of adolescents) that were observed to correlate with either active or non-active gaming [19]. We fitted multilevel models to correct for a potential clustering effect at the school and class levels. In the first multiple logistic regression, the dependent variable was active gaming for more or less than 1 h/wk. In the second multiple logistic regression, the dependent variable was non-active gaming for more or less than 7 h/wk. *P* values <.05 were considered to be statistically significant. The multiple imputations as well as all the analyses based on the imputed datasets were performed in STATA/SE 12.1. Finally, Spearman's correlation coefficients on the

complete cases were calculated to provide insight into relations between active gaming ≥1 h/wk and non-active gaming >7 h/wk and their potential correlates. This was done in IBM SPSS Statistics version 20.

Results

Participants

The mean age of the total group of participants (n=353) was 13.9 years (SD 1.5); the majority were male (60.6%; 214/353) and attended a high level of education (64.6%; 228/353). Of the 353 participants, 33.2% (117/353) played active games ≥1 h/wk, 33.2% (117/353) played non-active games >7 h/wk, and 9.9% (35/353) played both active games ≥1 h/wk and non-active games >7 h/wk.

Table 1 shows the descriptive statistics for the potential correlates for active (≥1 h/wk) and non-active gamers (>7 h/wk) separately. In general, participants had a positive attitude toward both active and non-active gaming and had friends who spent much time on non-active gaming. Furthermore, the participants had a positive attitude toward PA and thought the use of active and non-active games was easy.

Table 1: Means and standard deviations of potential correlates of active and non-active gaming (M (SD) or % high score) (n=353)

	Active gaming		Non-active gaming	
Characteristic (scale)	**Active gamers (≥1 hr/wk)**	**Active gamers (<1 hr/wk)**	**Non-active gamers (>7 hrs/wk)**	**Non-active gamers (≤7hrs/wk)**
Personal correlates				
Attitude towards playing active games (1-5)	3.5 (0.79)	3.1 (0.8)	3.1 (1.3)	3.3 (0.6)
Attitude towards playing non-active games (1-5)	3.3 (1.0)	3.4 (0.8)	3.8 (0.9)	3.2 (0.6)
Autonomous motivation for playing video games (-30 through +30)	3.8 (4.4)	4.1 (3.2)	4.5 (4.3)	3.7 (3.1)
Self-perceived gaming competence (1-5)	3.2 (1.8)	3.3 (1.2)	3.8 (1.6)	3.0 (1.1)
Habit regarding playing video games (1-5)	2.7 (1.9)	2.6 (1.2)	3.5 (4.3)	2.3 (1.0)
Attitude towards physical activity (1-5)	4.2 (1.4)	4.3 (0.9)	4.0 (1.3)	4.4 (0.8)
Social correlates				
Descriptive norm active gaming of … (% high score on descriptive norm scale) • Friends • Brothers/sisters	 21 29	 7 7	 10 11	 13 16
Descriptive norm non-active gaming of … (% high score on descriptive norm scale) • Friends • Brothers/sisters	 51 31	 47 34	 76 32	 35 33
Image regarding active gamers (1-5)	3.2 (0.9)	3.1 (0.7)	3.0 (1.0)	3.2 (0.6)
Image regarding non-active gamers (1-5)	3.3 (1.4)	3.4 (1.0)	3.8 (1.2)	3.2 (0.9)

	Active gaming		Non-active gaming	
Characteristic (scale)	**Active gamers (≥1 hr/wk)**	**Active gamers (<1 hr/wk)**	**Non-active gamers (>7 hrs/wk)**	**Non-active gamers (≤7hrs/wk)**
Game related correlates				
Perceived ease of use of playing active games (1-5)	3.9 (1.9)	3.7 (1.3)	3.7 (2.1)	3.8 (1.2)
Perceived ease of use of playing non-active games (1-5)	4.1 (1.7)	4.1 (1.1)	4.3 (1.6)	4.0 (1.1)
Game engagement (19-57)	31.1 (16.8)	31.0 (10.8)	35.6 (15.7)	28.7 (9.9)
Number of active games in possession	12.1 (61.7)	3.2 (15.3)	9.2 (14.7)	4.7 (14.7)
Number of non-active games in possession	37.5 (116.7)	35.8 (68.6)	54.5 (118.5)	27.3 (66.2)

Hr/week, hour per week; Hrs/week, hours per week; M, mean; SD, standard deviation
Means and standard deviations are shown based on results from 50 imputation for the missing values.

Correlates of Active Gaming

Next, we evaluated which factors correlated with active (≥1 h/wk) and non-active gaming (>7 h/wk) in multivariable analyses. The regression analyses revealed the following statistically significant correlates for active gaming (≥1 h/wk; Table 2): Personal: "attitude toward active gaming", "attitude toward non-active gaming", and "habit regarding playing video games." Social: "descriptive norm active gaming of friends", and "descriptive norm active gaming of brothers/sisters." Game-related: "game engagement." Active gamers (≥1 h/wk) had a more positive attitude toward active gaming, a less positive attitude towards non-active gaming, a higher score on habit strength regarding gaming, had brothers/sisters and friends who spend more time on active gaming, and scored lower on game engagement.

Table 2: Logistic regression analyses of correlates of active ≥1 hr/wk and non-active gaming >7 hrs/wk.

	Active gaming ≥ 1 hr/wk			Non-active gaming >7 hrs/wk		
	OR	**95% CI**	**P value**	**OR**	**95% CI**	**P value**
Personal correlates						
Attitude towards active gaming[a]	5.3	2.4 - 11.8	<0.001	0.5	0.23-1.0	0.052
Attitude towards non-active gaming[ab]	0.3	0.1- 0.6	0.002	2.6	1.1-6.3	0.035
Autonomous motivation for playing video games	1.0	0.8 – 1.1	0.58	1.1	0.96-1.3	0.14
Self perceived gaming competence	1.0	0.6 – 1.5	0.88	0.84	0.51-1.37	0.49
Habit regarding gaming[ab]	1.9	1.2- 3.2	0.008	3.0	1.7- 5.3	<0.001
Attitude towards PA	0.9	0.5-1.5	0.7	0.8	0.5 – 1.3	0.35
Social correlates						
Descriptive norm active gaming						
• Friends[a]	3.4	1.4-8.4	0.0089	0.57	0.20-1.65	0.30
• Brothers/sisters[a]	6.7	2.6-17.1	<0.001	0.54	0.17- 1.74	0.30
Descriptive norm non-active gaming						
• Friends[b]	1.3	0.6 -2.6	0.55	3.3	1.46-7.53	0.004
• Brothers/sisters	0.7	0.3-1.3	0.24	0.6	0.27-1.33	0.21
Image regarding active gamers	1.3	0.6 - 2.8	0.58	0.51	0.21-1.23	0.13
Image regarding non-active gamers[b]	0.9	0.5 -1.5	0.6	2.0	1.07 – 3.75	0.030
Game-related correlates						
Perceived ease of use of playing active games	1.2	0.8-1.7	0.31	0.94	0.64-1.39	0.75
Perceived ease of use of playing non-active games	0.9	0.6-1.3	0.49	1.24	0.78-1.96	0.36
Game engagement[a]	0.95	0.91-0.997	0.04	1.02	0.97-1.08	0.37
Number of active games owned	1.03	0.99-1.07	0.098	1.03	0.99-1.06	0.13
Number of non-active games owned	1.0	0.99-1.0	0.78	1.0	0.99-1.0	0.65

PA, physical activity; hr/week, hour per week; hrs/week, hours per week
Values are shown based on results from 50 imputation for the missing values (n=353).
Adjusted for demographics: gender, age, educational level
[a]Significant correlate for active gaming ≥ 1 hr/wk
[b]Significant correlate for non-active gaming >7 hrs/wk

Correlates of Non-Active Gaming

With respect to non-active gaming (>7 h/wk), the statistically significant correlates were Personal: "attitude toward non-active games" and "habit regarding playing video games." Social: "descriptive norm non-active gaming of friends", and "image regarding non-active gamers." None of the game-related correlates were significant. Non-active gamers (>7 h/wk) had a more positive attitude toward non-active games, had a higher score on habit strength regarding gaming, had friends who spend more time on non-active gaming, and a more positive image regarding non-active gamers.

Bivariate Associations

Table 3 presents the bivariate correlations between the potential correlates and active (≥1 h/wk) and non-active gaming (>7 h/wk) based on the complete case sample (N=250). Active gaming (≥1 h/wk) was significantly, strongly, positively correlated (r≥0.5) with the number of active games owned; significantly, moderately, positively correlated (r=0.3) with attitude toward non-active gaming and descriptive norm active gaming brothers/sisters; and significantly, weakly, positively correlated (r=0.1) with descriptive norm active gaming friends, image regarding active gamers, and perceived ease of use of active games.

Non-active gaming (>7 h/wk) was significantly, strongly, positively correlated (r≥0.5) with attitude toward non-active gaming, habit, and image regarding non-active games and significantly moderately, positively correlated (r=0.3) with self-perceived gaming competence, descriptive norm non-active gaming friends, perceived ease of use of non-active gaming, game engagement, and number of non-active games owned. A significant, moderate, negative association was observed with attitude toward physical activity. The highest correlation coefficient among the correlates was 0.58, indicating that colinearity is not a problem.

Table 3: Spearman's correlations between active gaming ≥1 hr/wk, non-active gaming >7 hrs/wk and potential correlates based on the complete case sample (n=250)

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. Active gaming ≥1 hr/wk	-.03	.34[c]	-.11	-.03	-.02	.04	-.01	.21[c]	.30[c]	.03	-.03	.17[b]	-.02	.18[b]	.003	-.01	.54[c]	.01
2. Non-active gaming >7 hrs/wk	__	-.09	.49[c]	.12	.41[c]	.58[c]	-.24[c]	-.04	-.07	.38[c]	-.02	-.06	.49[c]	-.02	.25[c]	.38[c]	-.07	.30[c]
3. Attitude towards active gaming		__	.06	.13[a]	.03	.05	.03	.10	.07	.06	.0	.36[c]	-.03	.27[c]	.11	.08	.42[c]	.07
4. Attitude towards non-active gaming			__	.26[c]	.50[c]	.53[c]	-.18[b]	.14[a]	-.12	.35[c]	.02	.05	.50[c]	.12	.38[c]	.39[c]	-.09	.37[c]
5. Autonomous motivation for playing video games				__	0.26[c]	.03	.06	.07	.07	.30[c]	.11	-.01	.16[a]	.11	.17[b]	.21[c]	.04	.12
6. Self perceived gaming competence					_	.53[c]	-.13[a]	.03	.04	.34[c]	.0	-.0	.49[c]	.02	.37[c]	.40[c]	.0	.29[c]
7. Habit regarding gaming						__	-.22[c]	.02	-.10	.37[c]	.05	.03	.54[c]	-.06	.24[c]	.54[c]	-.03	.36[c]
8. Attitude towards PA							__	.05	.11	-.09	.08	.01	-.12	.01	-.04	-.21[c]	.05	-.08
9. Descriptive norm active gaming friends								__	.17[b]	.15[a]	-.01	.14[a]	.05	.02	-.02	.09	.06	-.04
10. Descriptive norm active gaming brothers/sisters									__	-.06	.18[b]	-.01	-.07	.09	.10	.04	.32[c]	.08
11. Descriptive norm non-active gaming friends										__	.09	-.04	.37[c]	.02	.10	.30[c]	.05	.21[c]
12. Descriptive non-active gaming brothers/sisters											__	.03	-.02	.09	.02	.19[b]	.09	.08
13. Image regarding active gamers												__	.16[b]	.08	.04	.13[a]	.18[b]	.03
14. Image regarding non-active games													__	-.04	.25[c]	.37[c]	-.04	.39[c]
15. Ease of use active gaming														__	.42[c]	-.002	.16[a]	.10
16. Ease of use non-active gaming															__	.22[c]	.03	.27[c]
17. Game engagement																__	-.0	.28[c]
18. Number of active games owned																	__	.25[c]
19. Number of non-active games owned																		__

PA, physical activity; hr/week, hour per week; hrs/week, hours per week

[a]Correlation is significant at the 0.05 level (2-tailed); [b]Correlation is significant at the 0.01 level (2-tailed); [c]Correlation is significant at the 0.001 level (2-tailed).

Discussion

Overview

The aim of the present study was to examine correlates of active gaming ≥1 h/wk and non-active gaming >7 h/wk and to compare these correlates, taking demographics such as gender, age, and educational level into account. A greater understanding of these correlates contributes to understanding why people play active and non-active games and provides insight into potential barriers of and opportunities for intervention strategies attempting to substitute active game play for non-active game play.

The findings of the present study show that significant correlates of active gaming ≥1 h/wk include the personal factors attitude toward active gaming, attitude toward non-active gaming, habit regarding gaming, the social factors descriptive norm active gaming of brothers/sisters and friends, and the game-related factor game engagement (first research aim). Significant correlates of non-active gaming >7 h/wk include the personal factors attitude toward non-active gaming and habit regarding gaming, and the social factor descriptive norm non-active gaming of friends and image of non-active gamers (second research aim). When comparing correlates of active gaming with non-active gaming, it shows that attitude toward non-active gaming (although the direction differs), habit strength, and descriptive norms (active or non-active gaming) of friends are the only factors associated with both types of gaming (third research aim).

Sole Correlates of Active Gaming

Important correlate of active gaming ≥1 h/wk included the social factor descriptive norm active gaming of brothers/sisters, in line with previous studies that showed that the social aspect was important for ongoing participation in playing active games [14;45;46]. Furthermore, observational real life studies showed that active games are often played with siblings [19;47]. Because descriptive norm active gaming of brothers and sisters was the most important correlate for active gaming ≥1 h/wk, we recommend that active game intervention strategies focus on families instead of individuals.

Game engagement was a weak correlate for active gaming. Active gamers were a bit less likely to be engaged during playing games. Game engagement was measured with the validated GEQ, a questionnaire to measure the potential of an individual to become engaged in video games [43]. However, based on this study, we do not know if it refers to a trait in the sense that some adolescents become more easily immersed when gaming or a state in the sense that some games have stronger immersive qualities (or a mix).

A commonly expressed concern about active games is that only youth who like physical activity and are already physically active (and therefore not a target group for

health promotion interventions) will play active games. However, the findings of the current study do not support this concern because we found that attitude with respect to physical activity was unrelated to active game play ≥1 h/wk.

Sole Correlates of Non-Active Gaming

Image regarding non-active gamers was the only factor that solely correlated with non-active gaming. Adolescents playing non-active games >7 h/wk were more positive about the image of a non-active gamer. Image or prototype is a construct belonging to the Prototype Willingness model [39] and denotes the image that an adolescent associates with a behavior or the perceptions of the type of person who performs the behavior (in this case non-active gaming) [39]. The Prototype Willingness model has mainly been applied to risk behaviors such as drinking and smoking; to our knowledge, it has not been applied yet to gaming behavior. Image was mentioned as a factor during focus groups with adolescents about gaming, but only regarding active gaming [14;48]. Some New Zealand girls (10-12 years old) did not see themselves playing active games once they reached high school, because it could be embarrassing. They thought playing active games is less socially acceptable for older girls than for younger girls [48]. In focus groups with Dutch adolescents, it was mentioned that it was not "cool" to play active games on your own. However, in the current quantitative study, these findings were not confirmed, because image appeared only to be a correlate for non-active gaming and not for active gaming.

Comparison of Correlates of Active and Non-Active Gaming

Attitude appeared to be an important personal correlate for both active and non-active gaming. With respect to active gaming, on one hand, active gamers (≥1 h/wk) had a more positive attitude toward active gaming than adolescents who play active games <1 h/wk. This result suggests that it is important that adolescents have a positive attitude toward active gaming when aiming to replace non-active games with active games. On the other hand, we found that attitude toward non-active games was strongly negatively associated with active gaming ≥1 h/wk. Because of the cross-sectional design of the study, we do not know whether becoming an active gamer for ≥1 h/wk results in becoming less positive about non-active games or whether adolescents who are less positive about non-active games are more likely to turn to active games. The first could be positive for intervention strategies aiming at replacing non-active games with active ones. However, it might also be true that the more adolescents enjoy and favor non-active games, and thus form an important target group, the less likely they are to replace their non-active game play with active games, and therefore form a target group that is difficult to reach. Attitude toward non-active games was also a correlate for non-active gaming >7 h/wk. Attitude toward non-active gaming was negatively associated with active gaming ≥1 h/wk and positively associated with non-active gaming >7 h/wk, which suggests it might be difficult to transform non-active gamers into active gamers.

Enjoyment is an important element of attitude, and intervention strategies should therefore consider the aspects that adolescents like about active games, namely, being physically active, interactivity, realistic body movements, one-to-one translation of their movements into the game, and playing with other people [14]. Although studies have shown that many adolescents enjoy playing active games, in the long term, boredom often strikes and use declines over time [14,15,46]. The aspects of video games that make them attractive in the long term are online modus, multiplayer options, and the opportunity to improve oneself [14]. Lyons et al showed that multiplayer options were prevalent in half of the 18 evaluated active games [49]. The most prevalent behavioral strategy was performance feedback (in 17 of the 18 active games), which opens up the opportunity to improve oneself. To ensure long-term enjoyment in active gaming, it is important that more active games include one of these features and that game developers develop more active games that remain enjoyable in the long run.

Habit strength was associated with both active ≥1 h/wk as well as non-active gaming >7 h/wk, suggesting that playing both types of gaming is a habitual activity. This is an interesting finding for future interventions targeting game behavior because habitual behaviors may be more difficult to change and require different strategies than nonhabitual behaviors [50]. For example, intervention strategies based on information provision might not be effective because the habitual behavior (gaming) may override the attentional mechanisms needed to process such information [51,52]. Habits are triggered by situational and environmental cues; therefore, behavior change strategies should focus on incorporating environmental cues [53]. For strategies aimed at replacing non-active games with active games, one may consider placing the active game console in a highly visible place so that it can serve as a cue for playing. On the other hand, the non-active game console should be placed in a less visible place to prevent it from serving as a cue for playing. Findings from a focus group study confirm that seeing an active game console serves as a cue for playing it [14].

Descriptive norm non-active gaming of friends was a correlate of non-active gaming >7 h/wk. Adding the finding that descriptive norm active gaming of friends was a correlate for active gaming ≥1 h/wk makes modeling behavior of friends an important factor for game behavior. Remarkably, non-active game behavior of brothers and sisters was not associated with non-active gaming >7 h/wk, because active game behavior of brothers and sisters was for active gaming ≥1 h/wk.

Limitations and Strengths

The present study is subject to some limitations that need to be acknowledged. First, the cross-sectional design precludes any inferences from being made about causal mechanisms. Second, all measures were based on self-reported information, which may suffer from recall bias and socially desirable answers. Although we based the measures upon readily existing instruments, some of the scales had to be shortened to avoid a lengthy

questionnaire. Doing so might have influenced the validity of the included measures. However, if a scale was shortened, we removed the items with the lowest factor loading, minimizing the possible negative influence on validity. Nevertheless, the use of selected items from validated scales is a limitation of the present study. Furthermore, we chose cutoff values for active and non-active gaming of 1 and 7 h/wk, respectively, which is arbitrary. There are no recommendations for the maximum time spent playing video games; therefore, we based our cutoff values on the results of previous studies and calculations for recovering the energy imbalance estimations [19-21,23].

One important strength of the current study is that it is the first to compare correlates of both active and non-active gaming. Furthermore, we included a wide range of personal, social, and game-related variables, which were based on behavioral theories and the outcomes of focus groups. The current study provides important new insights into personal, social, and game-related correlates of both active and non-active gaming.

Conclusions

Various factors were significantly associated with active gaming ≥1 h/wk and non-active gaming >7 h/wk. Active gaming is most strongly (negatively) associated with attitude with respect to non-active games, followed by observed active game behavior of brothers and sisters, and attitude with respect to active gaming (positive associations). On the other hand, non-active gaming is most strongly associated with observed non-active game behavior of friends, habit strength regarding gaming, and attitude toward non-active gaming (positive associations). Habit strength was a correlate of both active and non-active gaming, indicating that both types of gaming are habitual behaviors. Although these results should be interpreted with caution because of the limitations of the study, they do provide preliminary insights in potential correlates of active and non-active gaming, which can be used for further research as well as preliminary direction for the development of effective intervention strategies for replacing non-active gaming by active gaming among adolescents.

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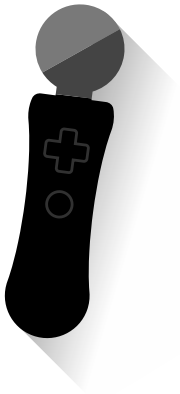
CHAPTER 6

Active video games as a tool to prevent excessive weight gain in adolescents: rationale, design and methods of a randomized controlled trial



Monique Simons
Mai Chinapaw
Maaike van de Bovenkamp
Michiel de Boer
Jaap Seidell
Johannes Brug
Emely de Vet

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Abstract

Background

Excessive body weight, low physical activity and excessive sedentary time in youth are major public health concerns. A new generation of video games, the ones that require physical activity to play the games –i.e. active games– may be a promising alternative to traditional non-active games to promote physical activity and reduce sedentary behaviors in youth. The aim of this manuscript is to describe the design of a study evaluating the effects of a family oriented active game intervention, incorporating several motivational elements, on anthropometrics and health behaviors in adolescents.

Methods/Design

The study is a randomized controlled trial (RCT), with non-active gaming adolescents aged 12 – 16 years old randomly allocated to a ten month intervention (receiving active games, as well as an encouragement to play) or a waiting-list control group (receiving active games after the intervention period). Primary outcomes are adolescents' measured BMI-SDS (SDS = adjusted for mean standard deviation score), waist circumference-SDS, hip circumference and sum of skinfolds. Secondary outcomes are adolescents' self-reported time spent playing active and non-active games, other sedentary activities and consumption of sugar-sweetened beverages. In addition, a process evaluation is conducted, assessing the sustainability of the active games, enjoyment, perceived competence, perceived barriers for active game play, game context, injuries from active game play, activity replacement and intention to continue playing the active games.

Discussion

This is the first adequately powered RCT including normal weight adolescents, evaluating a reasonably long period of provision of and exposure to active games. Next, strong elements are the incorporating motivational elements for active game play and a comprehensive process evaluation. This trial will provide evidence regarding the potential contribution of active games in prevention of excessive weight gain in adolescents.

Trial registration

Dutch Trial register NTR3228.

Introduction

Excessive body weight, low physical activity and excessive sedentary time in youth are major public health concerns [1-3], especially among children and adolescents from lower educated [4] and ethnic minority parents [5]. Obesity is associated with an increased risk for a range of chronic diseases and presents a major burden of disease and health care spending [6-8]. One of the life stages that may play a critical role in the development and persistence of obesity and related co-morbidities into adulthood is adolescence [9;10]. The adolescent period is characterized by low physical activity, high levels of sedentary behavior and changes in body composition (amount and location of body fat), making adolescents an important target group for preventive strategies [9].

Overweight and obesity generally result from a long-term imbalance between energy intake (determined by dietary intake) and energy expenditure (mainly determined by physical activity and sedentary behaviors) [11]. Regarding the latter, sedentary activities such as watching TV and playing video games, have been found to be associated with negative health outcomes such as overweight and obesity, partly independent of diet and moderate to vigorous physical activity [12-16]. It has been suggested that reductions in sedentary behavior may be as effective as or even more effective than increasing physical activity directly in decreasing BMI, and percentage overweight [17]. A major and increasing contributor to sedentary behavior is playing video games, a wide spread and popular activity among adolescents [18-20]. In the USA, an average of almost two hours per day playing video games was reported for 8–18 year olds, with an increase of almost one hour per day from 1999 to 2009 [18]. Recent evidence indicates that in the Netherlands, about 80% of the adolescents (12–16 years old) play video games regularly and play on average five days a week with an average duration of 65 minutes on a school day and 80 minutes on a weekend day [19]. In the Netherlands time spent on playing video games seems to peak during adolescence [20;21].

Reducing time spent in sedentary video games (hereafter called non-active games) may thus contribute to reducing sedentary time and prevention of overweight and obesity in adolescents. A new generation of video games, the ones that require physical activity to play the games –i.e. active games– seems a promising alternative to traditional non-active games to promote PA and reduce sedentary behaviors in youth. These active games, such as provided by and on Nintendo Wii, Microsoft Kinect, and Sony PlayStation Move, require whole-body movement to play the video game instead of the small movements of fingers and wrists used in non-active gaming [22]. Results from various studies have suggested that energy expenditure may be substantially increased when playing active games compared to energy expenditure during non-active gaming and other sedentary screen activities such as watching television [23;24]. Active games can generally elicit light to moderate intensity physical activity (2–6 metabolic equivalents; METS) [23;24]. Consequently, when adolescents substitute the time they spent

playing non-active games by playing active games, sedentary time will be reduced and physical activity increased, which may help to prevent excessive weight gain.

The potential strength of these active games is based on the intrinsic motivation of children to play video games. Intrinsic motivation is a construct based on the Self Determination Theory (SDT) and means that one enacts in an activity because one enjoys the activity and not because of external factors [25]. SDT posits that if one is intrinsically motivated, behavior change is more likely to be maintained [26]. Previous studies revealed that playing active games are perceived as fun and enjoyable [22]. Further, adolescents attending a low level of education are more likely to play active games frequently than those attending a higher level [19]. These results suggest that active games seem promising for reaching adolescents at risk, because they spend more time on non-active gaming and other sedentary behaviors [4;20] and are more likely to be overweight or obese [4].

Irrespective of energy expenditure, it can be hypothesized that active games may influence energy balance through reduced energy intake. Energy intake, especially the intake of snacks and sugar-sweetened beverages, is positively associated with time spent in sedentary screen activities such as watching TV and playing non-active games [16;27-30]. If active games can result in a decrease in sedentary time, it might simultaneously result in a lower energy intake. It is hypothesised that higher energy intake during sedentary activities is because they distract children from satiety cues [31]. It is possible that playing active games is less distractive than watching TV and playing non-active games [32]. On the other hand, it might also be that the physical activity required for playing active games influences appetite control [33] or may be thirst, resulting in a higher energy intake. However, up until now, little is known about energy intake during active gaming. So far only two studies have evaluated energy intake during playing active games [32;34]. Both studies showed no difference in energy intake while playing active games compared to energy intake while playing non-active games. However both studies were controlled laboratory studies and the effects of playing active at home on energy intake need to be further investigated. One randomized controlled trial with a 24-week follow-up showed a non-significant trend towards a decrease in self-reported energy intake from snacks in a home-based active gaming intervention group compared to a non-active game control group [35].

Substituting the time spent playing non-active games with playing active video games may thus reduce sedentary time, increase physical activity, reduce snacking and thereby prevent excessive weight gain in adolescents. So far only few and small scale studies have been conducted indicating that active games can decrease sedentary behavior and increase physical activity in youngsters on the short term (8 to 12 weeks) [36-39]. Other studies show that ongoing participation in active games is a problem [40;41]. To date only one well powered randomized controlled trial (RCT) on the effects

of an active gaming intervention on body composition with a longer follow-up period has been conducted [35]. This trial showed a small effect of a six-months active game intervention on Body Mass Index (BMI) and body composition in 10–14 year old overweight/obese children. More evidence is needed from adequately powered studies, also including normal weight children, monitoring long term participation in the active games, and investigating long term effects [23;42].

Therefore, the current study aims to evaluate an active game intervention that incorporates motivational elements for adherence, includes a long intervention period and a comprehensive process evaluation. The intervention of the current study has four unique features that make this study worthwhile. First, so far no active game interventions were family-oriented. Parental involvement in interventions for children and adolescents has been recommended, therefore the current trial includes the family instead of only the individual adolescent [43]. Furthermore, games are often played at home and it has been recommended to change the obesogenic home environment to better facilitate and enable weight gain preventive behaviors [43]. Secondly, the current study includes several elements to promote active game play based on previous studies, such as encouraging social play and providing a variety of active games [22;44]. This is important because previous studies showed that maintaining participation in active game participation is difficult to achieve when providing active games without any additional efforts to encourage use [37;40;41]. Thirdly, previous studies mainly focused on the first generation of active games such as Dance Dance Revolution and PlayStation2®EyeToy [35-37;40;41], and as the gaming industry is evolving fast, there is a need for studies evaluating the newest generation of active games such as PlayStation® Move or Kinect games. Fourthly, to our knowledge the current study includes the longest follow up period (ten months) for an active game intervention.

The current manuscript describes the design of a trial evaluating the effects of a family-oriented active game intervention, incorporating several motivational elements. The overall study focuses on both the adolescents as well as his or her family members. The current manuscript focuses on the measurements and effectiveness among adolescents. The intervention consists of a) providing an upgrade package for the newest generation of active games (PlayStation®Move), b) an encouragement to replace at least 1 hour of non-active gaming by active gaming on the PlayStation Move, c) stimulating social play by providing an extra Move controller, and d) stimulating long term use by providing multiple active games.

We will test the following hypotheses:

1) The intervention will result in lower BMI-SDS (SDS = adjusted for mean standard deviation score using the 1997 Dutch growth study as reference), waist circumference-SDS, hip circumference and skinfold thickness compared to the control condition after four and ten months.

2) The intervention will lead to less self-reported time on sedentary screen activities compared to the control condition after four and ten months.
3) The intervention will lead to less self-reported sugar-sweetened beverages and snacks consumption compared to the control condition after four and ten months.

Methods/Design

Design

The efficacy of the active game intervention is evaluated in a randomized controlled trial among adolescents aged 12 to 16 years old and their families. Families are randomly assigned to the intervention or control group after baseline assessment by the researcher or research assistant using a pre-determined randomization list. The randomization list consists of a row with the numbers one and two in a random order and is based on a block randomization scheme, with blocks of 100, obtained from an online computer program (http://www.randomization.com). Participants are assigned to one of the research groups based on this randomization list in order of checking out after they finish the baseline measures. The intervention group is exposed to the active game intervention and the control group is asked to continue their normal game play behavior and they receive the material belonging to the intervention at the end of the study. Measures are taken at baseline (T_0) (adolescent anthropometrics and questionnaire), after one month (T_{1m}) adolescent questionnaire (including process evaluation for intervention group adolescents), four months (T_{4m}) adolescent anthropometrics and questionnaire (including process evaluation for intervention group adolescents); and ten months (T_{10m}) adolescent anthropometrics and questionnaire (including process evaluation for intervention group adolescents) (Table 1). Primary outcomes are adolescents' measured BMI-SDS (SDS = adjusted for mean standard deviation score), waist circumference-SDS, hip circumference and skinfolds thickness. Secondary outcomes are adolescents' self-reported sedentary behavior, and consumption of sugar-sweetened beverages and snacks. Additionally, physical activity behavior excluding active game play is assessed to check whether the active game intervention was at the expense of physical activity.

The study was approved by the Medical Ethics Committee of the VU Medical Centre.

Table 1: design scheme

	Measure moment			
Measures	T_0	T_{1m}	T_{4m}	T_{10m}
Anthropometrics (weight, height, waist and hip circumference, skinfolds)	x		x	x
Questionnaires				
Time spent active and non-active gaming	x	x	x	x
Physical activity and sedentary screen time	x	x	x	x
Consumption of snacks and sugar sweetened beverages	x	x	x	x
Companions for active / non-active gaming				x
Game consoles and applications owned	x	x	x	x
Process evaluation (only in intervention group)				
1) Adherence to the intervention				
Usage of Move games		x	x	x
Reasons for not playing (the minimal of one hour per week)		x	x	x
2) Opinion of the Move games and the intervention				
Enjoyment with respect to playing the Move games		x	x	x
Most played Move game		x	x	x
Most enjoying Move game		x	x	x
Ease of use		x	x	x
Perceived competence		x	x	x
Perceived physical exertion of playing Move games				x
Opinion on the amount of provided Move games				x
Self purchased Move game				x
3) Game context				
Move game companions				x
Location of PlayStation Move console				x
4) Potential adverse effects (occurrence of injuries because of playing with the Move games)				x
5) Activity replacement			x	x
6) Intention to continue playing the Move games				x

T_0 =baseline measurement; T_{1m} =measurement one month after baseline; T_{4m}= measurement four months after baseline; T_{10m}= measurement ten months after baseline.

Blinding

It is not possible to perform the randomization blind, because based on the randomization the adolescents receive an active game upgrade package or not. At T_0 the measures are conducted blind for participants and research assistants regarding group assignment. At the end of the T_0 measure the randomization takes place and therefore the measures at T_{4m} and T_{10m} cannot be conducted blind for participants or assessors. The intervention group receives new games at T_{4m} and the control group receives their Move package at T_{10m}. Data analyses are not conducted blind.

Participants

The current study focuses on adolescents aged 12–16, who are the main participants of the study. Additionally the family members of the adolescent (parents and siblings aged 8–18 years old) are included in the study but they are not used for current analyses. Inclusion criteria are:

- Adolescent plays ≥ 2 hours of non-active video games per week
- Adolescent does not play active games yet, or less than once a week.
- Adolescent is physically and mentally able to play active games
- Adolescent has access to a PlayStation3 in his or her home.
- Family does not have a Move upgrade for PlayStation3
- Adolescent lives in the participating household (assuring sufficient access to the Move games provided as part of the intervention) at least 4 days a week.
- At least one family member (parent or sibling aged 8–18 years old) is willing to participate in the study (filling in questionnaires).

Sample size

Sample size calculation is performed to estimate how many adolescents should be included to detect a significant difference of 0.5 kg excess body weight between the intervention and control condition during the follow-up measurements (primary analysis). The 0.5 kg excessive weight gain is based on calculations in adults, because calculations for adolescents were lacking at that time. Adult individuals may gain on average 0.5 kg excess body weight per year, which results from an energy imbalance of only 70 Kcal per week per year [43]. We computed, based on energy expenditure studies, that an excess weight gain of 0.5 kg, may be prevented by substituting one hour per week of non-active gaming by playing active games [45]. To have sufficient power to detect a clinically relevant difference in excess weight gain of 0.5 kg (SD =1.5 kg) between the intervention and control condition during follow up, with a power of 0.80, alpha .05 and an intraclass correlation coefficient (ICC) for within-subject clustering of observations of 0.7, 99 participants in each condition are needed. Taking into account an anticipated drop-out of 20%, a total of 119 adolescents per condition needs to be recruited.

Recruitment

Recruitment of adolescents takes place in four cities in the Netherlands: Amsterdam, Amersfoort, Leiden and Breda. Advertisements are posted on game websites, game magazines, Facebook, newsletter for PlayStation owners and local papers, and announcements are made on local radio. In addition, local health organizations (GGD) and municipalities in the four cities collaborate by providing addresses of families with a child aged 12–16 years old. In Leiden all families with a 12–16 years old child receive an invitation letter, and in Amsterdam, Breda and Amersfoort we make a selection based on postal code areas covering neighborhoods with a relatively low social economic status. Also, flyers are distributed in schools and popular places for gaming adolescents (e.g. game shops, music stores). Interested adolescents and families can provide their contact details on our project website or send it by mail. The interested families are contacted by email and asked to complete an online questionnaire to assess further inclusion criteria. Next, eligible families receive information about participation and an informed consent form that they have to fill in prior to the baseline measure. Then, families receive information about the baseline online questionnaires and an invitation for the adolescent's baseline assessment.

Intervention

Adolescents assigned to the intervention group receive a PlayStation®Move upgrade package to play active games on a PlayStation3 console. PlayStation®Move uses a handheld motion controller wand and a motion-capture PlayStation®Eye camera that tracks the position, and inertial sensors in the wand to detect its motion. In this way every movement of the player is mimicked on-screen in the game. Although, there are multiple active game systems (such as Nintendo Wii, Dance Dance Revolution, Microsoft Xbox Kinect, PlayStation2®EyeToy) available on the market, the PlayStation®Move was chosen for the current study for several reasons. First, a survey study showed that the PlayStation was the most frequently owned game console among 12–16 year old adolescents [19]. So by choosing an application that is compatible with the PlayStation, we optimize the chances for recruiting sufficient participants. Second, the active game system for the PlayStation is one of the newest on the market at time of the study, making use of the most sophisticated technology, and may be more affordable (around €50) than other consoles or active game upgrades (e.g. Microsoft Kinect (around €135)).

As mentioned in the introduction previous studies showed that attention should be paid to (ongoing) participation in active game play, therefore we include several motivation enhancing intervention elements. Since variation in games is important [22;46;47], families receive four active Move games (Sport Champions, Move Fitness, Start the Party and Medieval Moves) at the start of the study and two more (Dance Star Party and Sorcery) after four months. Social and family play is important [22;44], and we provide two controllers to promote playing together with family and friends. Further, research has shown that providing instruction to use the active games seems an important addition to providing

the games for physical activity promotion [46;48], therefore we explicitly encourage participants at each contact moment to substitute non-active gaming with active gaming as much as possible but at least one hour per week. One hour per week corresponds with approximately 70 kcal (representing the energy imbalance that can result in excessive weight gain) [43], and was regarded as a feasible change.

Adolescents in the control group are asked to continue their normal gaming behavior. They receive a PlayStation Move starters pack at the end of the study as an incentive for their participation. Further, they receive a small gift (e.g. magazine, lanyard, pen) as an incentive after participation at each measure moment.

Measurements

Adolescents' anthropometrics ($T_{0,}$ $T_{4m,}$ T_{10m}) (primary outcomes)

Adolescent's anthropometric measures: height, weight, waist and hip circumferences and skinfolds thickness are performed at T_0, T_{4m} and T_{10m} on pre-scheduled days at central places in the same four cities where we recruited the participants. These measurements take place at a site close to where the participants live (a museum, school or soccer stadium). Adolescents who are incapable to visit during the pre-scheduled days are measured at home. Trained research assistants conduct the measurements in an accurate manner according to a standardized protocol.

Height is measured to the nearest 0.1 cm using a Seca type 214 stadiometer with adolescents standing on bare feet and their head in the Frankfort plane. Weight is measured on bare feet with a calibrated electronic scale (SECA) with an accuracy of 0.1 kg. Adolescents are allowed to wear light indoor clothing, such as a t-shirt and shorts/short pants, and are asked to remove belt or any other heavy objects of use such as phone, keys or wallet. BMI (kg/m^2) is calculated by dividing weight (kg) by height squared (m^2). Next, BMI-SDS is determined using the data from the fourth Dutch growth study among children of 1997 as reference [3] employing the Growth Analyser software (https://www.growthanalyser.org/). Waist and hip circumference are measured with a tape measure (brand Jobst) to the nearest 0.1 cm. For waist circumference we also determine the SDS values using the same reference group and software as for BMI. Skinfolds are measured with an accuracy of 0.2 mm using four-site skinfold measures (triceps, biceps, subscapular and suprailiac) with a Harpenden skinfold calliper [49]. For hip circumference and skinfold thickness valid Dutch reference data to calculate SDS scores are not available.

At least two readings of each measurement (weight, height, waist/hip circumference and skinfolds) are obtained to deal with intra-observer variability, and the mean of the two measurements is used for analyses. If the two readings differ more than 1 cm for height, more than 0.2 kg for weight, more than 1 cm for waist and hip circumference, more than 1 mm for skinfolds, a third measurement is taken. In case of three measurements, the outlier of the three will be excluded.

Self-reported measures

Online questionnaires (made with the online tool NETQ http://www.netq-enquete.nl/nl) are emailed to the adolescents at T_0, T_{1m}, T_{4m} and T_{10m}. The questionnaires assess demographics birth date, sex, educational level (pre-vocational; higher continued education; pre-university) and country of birth. Also active and non-active gaming behavior, other energy balance related behaviors, game consoles/application owned and game companions are assessed in the questionnaires (Table 2). Among the adolescents in the intervention group a process evaluation is conducted. Several process evaluation questions are added in the questionnaire of the intervention group at T_{1m}, T_{4m}, T_{10m} (Table 3). Furthermore, adolescents in the intervention group are asked to report their use of the Move games over the entire ten-month period using a calendar format.

Time spent active and non-active gaming (T_0, T_{1m}, T_{4m}, T_{10m})

To assess time spent active and non-active gaming, questions are formulated based on existing and validated questionnaires for adolescents asking about frequency and duration, for school and weekend days separately [50,58]. Adolescents can indicate the duration by selecting one of four categories (<30 minutes, 30–60 minutes, 1–2 hours, and >2 hours). Average values are calculated for every category (<30 minutes =15 minutes; 30–60 minutes =45 minutes; 1–2 hours =90 minutes; >2 hours =150 minutes) and multiplied by the frequency, resulting in total hours per week spent on active and non-active games separately.

Other physical activity and sedentary screen time (T_0, T_{1m}, T_{4m}, T_{10m})

Assessment of physical activity and sedentary screen time occurs by determining the frequency and the amount of time spent on different leisure-time sedentary and physical activities based on the validated Flemish Physical Activity Computer Questionnaires (FPACQ) [51]. The FPACQ assesses physical activity and sedentary behavior in multiple domains: school activity (physical activity and sports participation at school excluding physical education lessons), active transport (transportation for example by bike, and walking (for both school and leisure time), non-active transport (transportation for example by car or bus (for both school and leisure time) leisure time sports participation, and sedentary activities (watching television and computer activities). For the current study we focus on the domains active transport and leisure time sports participation for physical activity. Physical activity outcomes are leisure time sport behavior (MET*hours per week), active transport to school (minutes per week) and walking and cycling in leisure time (minutes per week). Sports participation in MET*hours per week is calculated by multiplying the reported hours per week by their corresponding MET values according to the compendium of MET values [59]. For sedentary screen time we focus on computer time (hours per week) and TV time (hours per week). Computer time includes all activities on a computer such as chatting and surfing on the Internet, except playing computer games. Both computer and TV time are assessed separately for week- and weekend days.

Consumption of snacks and sugar sweetened beverages (T_0, T_{1m}, T_{4m}, T_{10m})

Consumption of sugar-sweetened beverages is assessed using questionnaires by Van der Horst et al. [52]. Consumption of sugar-sweetened beverages includes consumed glasses, cans and bottles of carbonated and non-carbonated soft drinks, lemonade, and sport and energy drinks. Diet sodas and juices are not assessed. Total consumption of sugar sweetened beverages is expressed in liters per day, and is calculated according to Dutch standard serving sizes (1 glass = 200 ml, 1 can = 330 ml, 1 bottle = 500 ml). Consumption of snacks is assessed using items from a validated questionnaire [52;53]. Snacks are classified as savory (e.g. fast-food, pizza, fries, chips, nuts) or sweet (e.g. candy, candy bars, chocolate, cake, biscuits) eaten between the main meals, and not as side servings at main meals. Quantity of consumed snacks is obtained by determining amount of "snack days" and amount of snacks consumed per "snack day". These questions are combined into a single score for the amount of portions snack intake per week.

Game consoles and applications owned (T_0, T_{1m}, T_{4m}, T_{10m})

At all measurements we assess which game consoles and game application the adolescents have access to in their home.

Game companions for active/non-active gaming (T_{10m})

At T_{10m} we assess with whom the adolescents usually play active and non-active games.

Table 2: Gaming aspects and behavior, physical activity, sedentary and dietary behavior assessed in questionnaires.

	Items and answering categories	Instrument/ source
Gaming aspects and behavior		
Time spent non-active gaming	1. How often do you play non-active games on weekdays? (1-5 days a week) 2. How long per day do you play non-active games on a weekday? (… hours; … minutes) 3. How often do you play non-active games on weekend days? (1-2 days a week) 4. How long per day do you play non-active games on a weekend day? (… hours; … minutes)	De Jong et al., 2013 [50]
Time spent active gaming	1. How often do you play active games on weekdays? (1-5 days a week) 2. How often do you play active games on weekend days? (1-2 days a week) 5. How often do you play active games on weekend days? (1-2 days a week) 6. How long per day do you play active games on a weekend day? (… hours; … minutes)	De Jong et al., 2013 [50]
Companions for active / non-active gaming	With whom do you usually play active/ non-active games? • by myself, • with my parents, • with my brother/sister, • with my friends, • with somebody else, namely …)	Specifically developed for the current study[1]
Game consoles and applications owned	Which consoles and application do you have at home? (PlayStation 1/2/3; PlayStation Move; PSP (PlayStation Portable); Xbox; Xbox 360; Kinect; (Super)Nintendo; Nintendo Wii; Nintendo DS(i); Gamecube; Gameboy; Dance Dance Revolution; EyeToy; Computer/ Laptop; iPad or another tablet)	Specifically developed for the current study[1]
Physical activity		
Sports	1. Which sports do you play in leisure time? 2. How often do you play these sports in leisure time? (1-7 times a week, > 7 times a week) 3. How long do you play these sports when you play them in leisure time (… hours; … minutes)	Flemish Physical Activity Computer Questionnaires [52]

Active transport *School* *Leisure time*	1. How do you usually go to school? (bike, walking, train/car/bus/scooter/moped, step,/ roller-skates/skateboard/wave board) 2. How long does it take to go from home to school (one way)? … minutes 3. Do you go home during lunch break? (yes; no) 4. On which days do you go home during lunch break? (Monday; Tuesday; Wednesday; Thursday; Friday) Weekdays 5. How long on a weekday do you usually walk in your leisure time to go somewhere (excluding walking to school, work or trainee post)? (0-10; 10-20; 20-30; 30-40; 40-50; 50-60 minutes per day; more than one hour per day (… hours and … minutes per day) 6. How long on a weekday do you usually cycle in your leisure time to go somewhere (excluding walking to school, work or trainee post)? (0-10; 10-20; 20-30; 30-40; 40-50; 50-60 minutes per day; more than one hour per day (… hours and … minutes per day) Weekend days 7. How long on a weekend day do you usually walk in your leisure time to go somewhere (excluding walking to school, work or trainee post)? (0-10; 10-20; 20-30; 30-40; 40-50; 50-60 minutes per day; more than one hour per day (… hours and … minutes per day) 8. How long on a weekend day do you usually cycle in your leisure time to go somewhere (excluding walking to school, work or trainee post)? (0-10; 10-20; 20-30; 30-40; 40-50; 50-60 minutes per day; more than one hour per day (… hours and … minutes per day)	
Sedentary screen time		
TV time	About how many hours a day do you watch television in a normal week? (excluding school time) • During weekdays: • …. hours; …. minutes • During weekend days: • …. hours; …. minutes	Flemish Physical Activity Computer Questionnaires [52]

Computer time	About how many hours a day do you spend on the computer (e.g. chatting, internet) in a normal week? (excluding non-active and active gaming) • During weekdays: • .... hours; .... minutes • During weekend days: • .... hours; .... minutes	
Dietary behavior		
Consumption of sugar sweetened beverages	Sugar-sweetened beverages were defined as carbonated soft drinks, other non-carbonated sugar sweetened drinks (water-based beverages that contain sugar) and so-called sport and energy drinks (e.g. AA, Extran, Aquarius, Red Bull). Excluding light or diet drinks and fruit juices. 1. On how many days a week do you usually drink soda? (1-7 days a week) 2. If you drink soda, how many soda do you drink on average on one day? • How many glasses/packages (250 ml)? (none, 1,2,3,4,5,6, 7 or more) • How many cans (330 ml)? (none, 1,2,3,4,5,6, 7 or more) • How many bottles (500 ml)? (none, 1,2,3,4,5,6, 7 or more) 3. On how many days a week do you usually eat cake or candy? (1-7 days a week) 4. If you eat cake or candy, how many do you eat on average on one day? • 1,2,3,4,5, 6 or more portions/pieces	Van der Horst et al. 2008 [54]
Consumption of snacks	Savory (fast-food, pizza, fries, chips, nuts). 1. On how many days a week do you usually eat snacks? • 1-7 days a week 2. If you eat snacks, how many do you eat on average on one day? • 1,2,3,4,5, 6 or more portions/pieces Sweet (candy, candy bars, chocolate, cake, biscuits) 3. On how many days a week do you usually eat cake or candy? • 1-7 days a week 4. If you eat cake or candy, how many do you eat on average on one day? • 1,2,3,4,5, 6 or more portions/pieces	Van der Horst et al. 2008; Van Assema et al., 2001 [54, 55]

[1]The questions that were specifically developed for the current study were based on focus groups and/or a previous survey study on active and non-active gaming among adolescents [19, 22] and were pilot-tested in gaming adolescents to assure understanding and face validity.

Process evaluation measures

A comprehensive process evaluation is conducted in the intervention group at T_{1m}, T_{4m}, T_{10m}. Findings from focus groups and a survey about active and non-active gaming in adolescents provided a rationale for evaluating the following six elements [19;22]: 1) adherence to the intervention (usage of Move games, reasons for not playing at least one hour per week), 2) opinion of the Move games and the intervention (enjoyment, most played Move game, most enjoying Move game, ease of use, perceived competence, perceived physical exertion of playing Move games, opinion on the amount of provided Move games, self purchased Move game), 3) Game context (Move game companions, location of PlayStation Move console), 4) potential adverse effects (occurrence of injuries because of playing with the Move games), 5) activity replacement and 6) intention to continue playing the Move games. Table 3 shows all the process evaluation concepts, the items and answering categories as assessed in the questionnaire.

In addition to the questionnaires, adolescents' time spent playing the active Move games in the intervention group is assessed on a daily basis over the whole 10-month period using a calendar format. The adolescents are asked to report type of Move game and amount of hours and minutes spent playing the Move games, according to Chinapaw et al. [41].

Table 3: Process evaluation measures assessed in intervention group

Process evaluation concepts	Items and answering categories	Instrument/source
1) Adherence to the intervention		
Usage of Move games	Did you succeed in playing the move games for at least one hour per week? • Yes, I played the move games for at least one hour per week • No, In some weeks I failed to play the move games for at least one hour • No, I never succeed in playing the move games for at least one hour per week	Specifically developed for the current study[1]
Reasons for not playing (the minimal of one hour per week)	Why did you not managed to play the move games for at least one hour per week? • I was too hot • I was not allowed by my parents • There was somebody else playing on the Move. • The move console did not worked properly • The move games did not respond well to my movements • I think the move games are too tiring • I think the move games are boring • We have not enough space to play to move games well • I had not enough move games • I did not have time • I think the move games are stupid • I had to many other things to do • There wasn't somebody to play with and it is boring to play the games by myself • I was injured • I rather play non active games • Other, namely …	Specifically developed for the current study[1]

Process evaluation concepts	Items and answering categories	Instrument/ source
2) Opinion of the Move games and the intervention		
Enjoyment with respect to playing the Move games	I enjoy playing the Move games (totally disagree (1) – totally agree (7)) Playing the Move games is fun to do (totally disagree (1) – totally agree (7)) I think playing the Move game is boring (totally disagree (1) – totally agree (7)) Playing the Move games could hold my attention totally disagree (1) – totally agree(7)) I would describe playing Move games as very interesting (totally disagree (1) – totally agree (7)) I think playing the Move games is quite enjoyable (totally disagree (1) – totally agree (7)) While playing the Move games, I was thinking about how much I enjoyed it (totally disagree (1) – totally agree (7))	Intrinsic Motivation Inventory (sub scale enjoyment). [58]
Most played Move game	Which game did you play most often?	Specifically developed for the current study[1]
Most enjoying Move game	Which game did you like the most?	Specifically developed for the current study[1]
Ease of use	It's easy for me to learn how the Move games work (totally disagree (1) – totally agree (5)) Playing the Move games is easy for me (totally disagree (1) – totally agree (5))	Davis, 1989; Hsu & Lu, 2004 [59, 60]

Process evaluation concepts	**Items and answering categories**	**Instrument/ source**
Perceived competence	I believe I am good in playing Move games (totally disagree (1) – totally agree (5)) I think I am better at playing the Move games than other people of my age and gender (totally disagree (1) – totally agree (5)) I am generally happy with my gaming performance (totally disagree (1) – totally agree (5))	Intrinsic Motivation Inventory (subscale competence). [58]
Perceived physical exertion of playing Move games	How would you rate the intensity level of playing the Move games? • Light, little body movements are required while playing on the Move, and my breath rate does not accelerate; • Moderate, I move my body quite a lot while playing on the Move and my breath rate accelerates a little bit; • Hard, I have to move a lot and fast, I get out of breath and I am sweating during playing on the Move	Specifically developed for the current study[1]
Opinion on the amount of provided Move games	What do you think about the amount of provided move games? (too little - exactly right - too much)	Specifically developed for the current study[1]
Self purchased Move game	Did you bought, received, borrowed or downloaded other Move games in addition to the games we provided you?	Specifically developed for the current study[1]
3) Game context		
Move game companion	With whom do you usually play the Move games? (by myself, with my parents, with my brother/sister, with my friends, with somebody else, namely ...)	Specifically developed for the current study[1]
Location of PlayStation Move console	Where was the PlayStation PlayStation®Move located most of the time? (Living room, my own bedroom, my brother's or sister's bedroom, in the attic, in a shared game room, somewhere else, namely ...)	Specifically developed for the current study[1]

Process evaluation concepts	Items and answering categories	Instrument/ source
4) Potential adverse effects		
Occurrence of injuries because of playing with the Move games	Did you hurt or injured yourself during playing with the Move? (yes; no) What kind of injury occurred during game play? (bruise; graze; strained muscles or tendons; bruised something (e.g. ankle, wrist); broke something (e.g. leg, wrist, arm); some other injury, namely ....)	Specifically developed for the current study[1]
5) Activity replacement	Can you think back about the time you did not have the Move games yet, what did you do with the time you now spend on active gaming?	Simons et al., (2012) [45]
6) Intention to continue playing the Move games.	1. I intend to continue playing the Move games; 2. I expect to continue with playing the Move games (totally disagree (1) – totally agree (5)).	Based on Theory of Planned Behavior [61]

[1]The questions that were specifically developed for the current study were based on focus groups and/or a previous survey study on active and non-active gaming among adolescents [19;22] and were pilot-tested in gaming adolescents to assure understanding and face validity.

Statistical analyses

First descriptive analyses are performed and data are checked for a normal distribution. Subsequently, control group and intervention group are described on baseline for demographics and outcome measures. Next, the effects of the intervention on all outcomes are evaluated by multilevel analyses. In the primary analyses, we analyze those participants which have at least one follow-up measurement in the groups they were randomized to. As a sensitivity analyses we will also impute follow-up measurements for persons with only a baseline measurement using multiple imputation with chained equations (intention to treat). Two models are constructed for each outcome measure: model 1 adjusts for the baseline value of the outcome measure; and model 2 additionally adjusts for demographics (age, sex, ethnicity and adolescent educational level) that are expected to associate with the outcome [3-5]. Second, analyses are performed according to the per protocol principle including the participants in the intervention group who played the Move games at least one hour per week. Adherence to protocol will be defined for each follow-up measurement separately, based on the question in the questionnaire assessing use of Move games (in hours per week) at T_{1m}, T_{4m} and T_{10m}. Again, two models are constructed for each outcome measure: model 1 adjusts for baseline outcome measure; and model 2 adjusts for demographics (age, sex, ethnicity and adolescent educational level) that are expected to associate with the outcome [3-5].

Additionally, a sensitivity analyses is performed by constructing all the models excluding the more extreme values on sedentary screen time (e.g. > 12 hours per day of non-active time). Further, if feasible (i.e. if the number of participants allows), explorative analyses are performed to check whether sex, age, adolescent educational level and ethnicity are effect modifiers, using a significance level of 0.10 because the study is not powered for detecting effect modification.

For the process evaluation, descriptive statistics are used describing the use of the Move games based on the Move game calendar over the ten months intervention period and the process evaluation measures. All statistical analyses are performed using IBM SPSS Statistics version 21 and statistical significance level is set at $P < 0.05$ for detecting main intervention effects and $P < 0.10$ for detecting effect modifiers.

Discussion

This paper describes the design of a trial to test the effects of a family oriented active game intervention on anthropometrics and self-reported behavior among adolescents. As mentioned in the introduction, the current trial on active games contributes to existing literature because it is one of the few adequately powered trials, includes normal weight adolescents, has a relatively long follow up period (ten months) and includes a comprehensive process evaluation. Further, the intervention uses the newest generation of active games and incorporates several motivational elements to encourage (maintenance of) active game play. Several studies have focused on overweight/obese children and showed that an active gaming intervention can result in small effects on BMI or body weight [35,60]. However, as far as we know the current trial is the first well powered RCT including normal weight adolescents. Furthermore, the comprehensive process evaluation will provide important insight into whether adolescents adhere to the active game intervention over a ten month period, whether they enjoy playing active games and the factors that hinder or encourage them to play the active games. This information can help to make future active game interventions more effective.

For the current study we chose to encourage the adolescents in the intervention group to substitute non-active gaming with active gaming as much as possible but at least one hour per week. The potential contribution of active games on prevention of excessive weight gain in adolescents, lies partly in the fact that adolescents are intrinsically motivated to play video games and active game interventions capitalize on this intrinsic motivation. As stated before behavior change is more likely to be maintained if one is intrinsically motivated, which means that one enacts in an activity because of the activity itself, because one enjoys the activity and not because of external factors [25]. Giving adolescents an encouragement to play the active games a minimum amount of time might conflict with this potential intrinsic motivation for active game play.

However, it is suggested that only providing active games is not enough to impact physical activity or body weight and it is important to also give an instruction regarding the use of the active games [46;48].

The encouragement for the intervention group to replace at least one hour per week of non-active gaming with active gaming, is based on calculations in adults demonstrating that excessive weight gain can be prevented if the energy balance is affected by 70 kcal per week. This was the best estimation that could be made when designing the study, because no child specific equation was available at that time. Recently, Hall et al. [61] developed and validated a model that quantifies the energy imbalance underlying excess bodyweight in children and calculates the necessary intervention magnitude to achieve bodyweight change in children. This model shows that around 116 extra kcal per week should be expended to prevent an excessive weight gain of 0.5 kg in children with an average age of 14 years old. As studies have shown that active gaming can elicit an energy expenditure of 381 kcal [23], one hour of active gaming (assuming it does not replace more vigorous activities such as sports) should in theory be sufficient to prevent excess weight gain in children.

A concern regarding promoting active game play is that active game play might replace traditional forms of physical activity (e.g. cycling, playing outside) because these activities elicit greater energy expenditure and may therefore contribute more to prevention of excessive weight gain than active gaming. In a descriptive Dutch study among active gaming adolescents and their parents, adolescents reported that they thought active gaming had replaced sedentary activities [45]. However, this was asked in retrospect after adolescents were already playing active games, and recall bias might have occurred. To get more insight in whether stimulating active gaming will lead to replacement of sedentary activities or whether it takes adolescents away from physical activities in which they already participate, the current study also evaluates the effect of providing active games on sedentary behavior and physical activity.

The present study is subject to some limitations that need to be acknowledged. Although we obtain the primary outcome measures objectively (e.g. adolescents' height, weight, waist/hip circumference and skinfolds), the secondary outcome measures (e.g. adolescents' physical activity, sedentary behavior, consumption of snacks and sugar-sweetened beverages) are self-reported and thus liable to social desirability and recall bias. However, this will occur in both groups resulting in potential bias towards the null.

In conclusion, this trial will provide important new information on the potential contribution of active games to the prevention of excessive weight gain in adolescents and the process evaluation will provide relevant information for future active games studies on factors hindering or promoting active game play.

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CHAPTER 7

Replacing non-active video gaming by active video gaming to prevent excessive weight gain in adolescents

Monique Simons
Johannes Brug
Mai Chinapaw
Michiel de Boer
Jaap Seidell
Emely de Vet

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Abstract

Objective

The aim of the current study was to evaluate the effects of and adherence to an active video game promotion intervention on anthropometrics, sedentary screen time and consumption of sugar-sweetened beverages and snacks among non-active video gaming adolescents who primarily were of healthy weight.

Methods

We assigned 270 gaming (i.e. ≥2 hours/week non-active video game time) adolescents randomly to an intervention group (n=140) (receiving active video games and encouragement to play) or a waiting-list control group (n=130). BMI-SDS (SDS=adjusted for mean standard deviation score), waist circumference-SDS, hip circumference and sum of skinfolds were measured at baseline, at four and ten months follow-up (primary outcomes). Sedentary screen time, physical activity, consumption of sugar-sweetened beverages and snacks, and process measures (not at baseline) were assessed with self-reports at baseline, one, four and ten months follow-up. Multi-level-intention to treat-regression analyses were conducted.

Results

The control group decreased significantly more than the intervention group on BMI-SDS (ß=0.074, 95%CI: 0.008;0.14), and sum of skinfolds (ß=3.22, 95%CI: 0.27;6.17) (overall effects). The intervention group had a significantly higher decrease in self-reported non-active video game time (ß=-1.76, 95%CI: -3.20;-0.32) and total sedentary screen time (Exp (ß=0.81, 95%CI: 0.74;0.88) than the control group (overall effects). The process evaluation showed that 14% of the adolescents played the Move video games every week ≥1 hour/week during the whole intervention period.

Conclusions

The active video game intervention did not result in lower values on anthropometrics in a group of 'excessive' non-active video gamers (mean ~ 14 hours/week) who primarily were of healthy weight compared to a control group throughout a ten-month-period. Even some effects in the unexpected direction were found, with the control group showing lower BMI-SDS and skin folds than the intervention group. The intervention did result in less self-reported sedentary screen time, although these results are likely biased by social desirability.

Trial Registration: Dutch Trial Register; registry number NTR3228;
http://www.trialregister.nl/trialreg/admin/rctview.asp?TC=3228

Introduction

Overweight and insufficient physical activity in youth are major public health concerns because of their associations with multiple chronic diseases [1-4]. Independent of physical activity, excessive sedentary time might also negatively affect health, although the evidence surrounding this issue is inconsistent [5,6]. The adolescent period is specifically characterized by a decline in physical activity [7,8], a high amount of sedentary screen time [9,10] and unfavorable changes in body composition (e.g. the amount and location of body fat) [11]. Adolescents are therefore an important target group for preventive interventions.

A common and popular activity among adolescents is playing video games [12-14]. Video games are often considered to be an important contributor to screen time and youth overweight [6,15,16]. However, video games are currently increasingly being explored as a means to promote physical activity and as a weight management tool [17-19]. Active video games, –i.e., video games that require physical activity to play-, can elicit light- to moderate-intensity physical activity [20,21] and might help to convert sedentary time into more active time. Studies have shown that many adolescents play active video games and enjoy playing them [12,22]. Hence, active video games might be capable of contributing to the prevention of excessive weight gain (i.e. weight gain that exceeds the weight gain required for regular growth).

In addition to increasing physical activity and decreasing sedentary behavior, active video gaming might have an additional effect on the prevention of overweight. Compared to non-active video gaming, active video gaming might provide fewer opportunities for snacking while gaming. In contrast active video gaming might also lead to increased intakes of snacks and beverages following the activity. The first studies that compared energy intake during active and non-active video gaming reported no differences [23,24]. However, these studies were controlled laboratory studies in adults [23] or used non-active video game performed on a treadmill for the active video game condition rather than a 'real active video game', such those played on the Wii, Kinect or PlayStation Move [24].

Thus far, there are a few large-scale randomized controlled trials (RCTs) that have evaluated the effects of active video games on body weight in adolescents [25]. Moreover, the majority of these studies focused on the treatment of overweight and obesity [26], included younger children [27,28] or evaluated active video games as part of a broader program [29]. Three large-scale RCTs have shown that active video gaming can beneficially affect body composition and overweight-related behaviors in overweight children [27-29]. However, the effects of providing active video games on the prevention of overweight in adolescents remain unclear.

The current trial aimed to evaluate whether providing active video games to non-active video gaming adolescents could contribute to the prevention of excessive weight gain. The adolescents were provided with the newest active video games to optimize engagement and an additional controller to facilitate the playing of the video games in multi-players modes. Furthermore, active video gaming was actively encouraged as a replacement for non-active video gaming.

We tested the hypotheses that four and ten months after randomization, the adolescents in the active video gaming intervention group would exhibit the following differences compared with the adolescents in the control group:

1. a lower body mass index adjusted for mean standard deviation score (BMI-SDS), a smaller waist circumference-SDS, a smaller hip circumference and a lower skin fold thickness
2. less self-reported time engaged in sedentary screen activities
3. lower self-reported intake of sugar-sweetened beverages and snacks.

To inform future active gaming studies and to gain additional more insight into the findings, a comprehensive process evaluation was conducted in the intervention group, to examine the following issues:

1) adherence to the intervention
2) appreciation of the Move video games and the intervention
3) game context
4) potential adverse effects (occurrence of injuries due to playing the Move video games)
5) activity replacement (i.e., activities that were replaced by active video gaming)
6) intention to continue playing the Move video games.

Methods

Design

The intervention was evaluated in a randomized controlled trial in adolescents aged 12- to 17-year-old adolescents. The study protocol has been described in detail in a separate publication [30]. The adolescents were randomly assigned to the intervention group or control group after baseline assessment by the researcher or a research assistant using a pre-determined computer-generated block randomization list with blocks of 100. The primary outcomes were the adolescents' BMI-SDSs, waist circumference-SDSs, hip circumferences and skin fold thicknesses. Measurements of the primary outcomes were collected at baseline and after four and ten months. The secondary outcomes were the adolescents' self-reported sedentary screen time and consumption of sugar-sweetened beverages and snacks. Additionally, physical activity behaviors excluding active video game play were assessed to determine whether the active video game intervention

resulted in less traditional (non-electronic game) physical activity. Measurements of the secondary outcomes were collected at baseline and after one, four and ten months.

The study was approved by the Medical Ethics Committee of the VU Medical Centre. The trial is registered in the Dutch Trial Register with number NTR3228 (http://www.trialregister.nl/trialreg/admin/rctview.asp?TC=3228).

Participants and recruitment

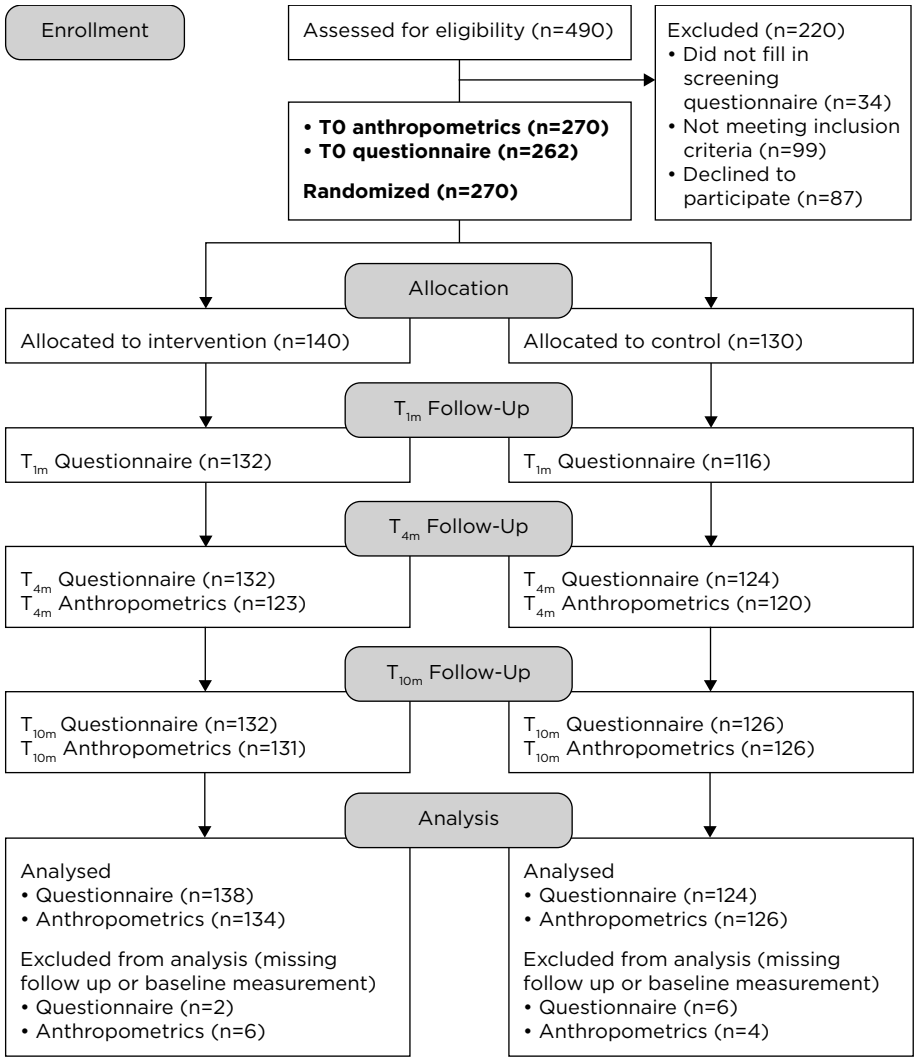
The current study focused primarily on adolescents aged 12-17 years. Additionally, the family members of the adolescent (i.e., parents and siblings aged 8-18 years) completed questionnaires, but these data were not included in the current analyses. The inclusion criteria were as follows:

- The adolescent played ≥ 2 hours of non-active video games per week.
- The adolescent played active video games less than once per week.
- The adolescent was physically and mentally able to play active video games (based on self-report).
- The adolescent had access to a PlayStation 3 at home.
- The family did not have a Move upgrade for the PlayStation 3.
- The adolescent lived in the same home as the participating family members at least 4 days per week (to enable sufficient access to the Move video games provided as part of the intervention, see below).
- At least one other family member (parent or sibling aged 8-18 years old) was willing to participate in the study (i.e., complete the questionnaires).

The recruitment of the adolescents occurred in four cities in the Netherlands; i.e., Amsterdam, Amersfoort, Leiden and Breda. Detailed information about the recruitment is described in Simons et al. [30]. Adolescents and family members interested in participating provided their contact details on our project website or via e-mail and subsequently received an online screening questionnaire by email to assess their eligibility based on the inclusion criteria. We assessed 490 families for eligibility (see Figure 1 for a participant flow chart). The eligible families received information about participation that included a written consent form that the adolescents and their parents were required to complete prior to the collection of the baseline measurements. The consent procedure was approved by the ethics committee. Next, the, families received information about the baseline online questionnaires and were invited to appointments to provide the adolescent's baseline measurements. Two hundred seventy adolescents showed up for the baseline measurements and were randomly allocated (140 to the intervention group and 130 to the control group). The sample size calculation (described in Simons et al. [30] indicated that we required 99 participants in each condition to have sufficient power to detect a clinically relevant difference in excessive weight gain of 0.5 kg (SD = 1.5 kg) between the intervention and control conditions during follow-up with a power of 0.80, alpha .05 and an intraclass correlation coefficient (ICC) for within-subject

clustering of observations of 0.7. Based on an anticipated drop-out rate of 20%, a total of at least 119 adolescents per condition needed to be recruited. The 0.5 kg excessive weight gain was calculated based on adults, because calculations for adolescents were not available during the design of the study. On average adults gain 0.5 kg of excessive body weight per year due to an energy imbalance of 70 Kcal per week per year [31]. Based on energy expenditure studies, we calculated that an unnecessary weight gain of 0.5 kg might be prevented by substituting one hour per week of non-active video gaming with active video gaming [32]. In other words, we assumed that both groups would gain body weight but that the intervention group would gain 0.5 kg less than the control group due to the extra energy expenditure of playing the active video games.

Figure 1: Participants flow diagram



Intervention

The adolescents assigned to the intervention group received a PlayStation Move upgrade package to play the active video games on a PlayStation 3 console in their homes. The PlayStation Move uses a handheld motion controller wand, a motion-capture PlayStation Eye camera that tracks the player's position and inertial sensors in the wand that detect its motion. Thus, every movement of the player is mimicked on-screen in the game. The following active video games were provided during the intervention: Sport Champions, Move Fitness, Start the Party and Medieval Moves, Dance Star Party and Sorcery. A detailed description of these Move video games can be found at: http://nl.playstation.com/ps3/games/.

Although, there are multiple active video game systems we chose for the PlayStation Move because the PlayStation appeared to be the most frequently owned video game console among 12-16 year old adolescents [12]. So by choosing an application that is compatible with the PlayStation, we optimized the chances for recruiting sufficient participants. Second, the active video game system for the PlayStation is one of the newest on the market at the time of the study, making use of the most sophisticated technology, and may be more affordable (around €50) than other consoles or active video game upgrades (e.g. Microsoft Kinect (around €135).

We included three elements to support continuing active video game play: 1) because variation in video games is important [22,33,34] the participants in the intervention group received four active Move video games with different game genres (Sport Champions, Move Fitness, Start the Party and Medieval Moves) at the beginning of the study and two additional video games (Dance Star Party and Sorcery) after four months; 2) because social and family play is important [22,35], we provided two controllers to promote playing together with family and friends; and 3) at each contact moment we explicitly asked and encouraged the participants to substitute non-active gaming with active gaming as much as possible and for at least one hour per week. One hour per week corresponds to approximately 70 kcal (which is equivalent to the energy imbalance that can result in unnecessary weight gain) [31] and was regarded as a feasible change [32].

Adolescents in the control group were asked to continue their normal gaming behavior. They received PlayStation Move starter packs at the end of the study as an incentive for their participation. Further, they received a small gift (e.g., a magazine, lanyard, or pen) as an incentive after participation at each measure moment.

Procedures

The participants started in three waves for which baseline measurements were collected in January/February 2012, March 2012, and June 2012. The participants completed online questionnaires at baseline and at one, four and ten months of

follow-up. Anthropometric measurements were collected at baseline and after four and ten months. Anthropometric measurements were conducted by trained research assistants according to a standardized protocol and occurred on pre-scheduled days at a central and attractive location (e.g., a museum or a soccer stadium). Adolescents who were unable to attend to central measurement location on the specified day were measured at home.

Blinding

It was not possible to keep the participants blinded to the treatment allocation because the intervention group received an active video game upgrade package, and the control group did not. The participants and research assistants were blinded to group assignment at T_0 but were not blinded atT_{4m} and T_{10m}. The data analyses were not conducted in a blinded manner.

Measurements

Adolescents' anthropometrics (T_0, T_{4m}, T_{10m}) (primary outcomes)

All measurements are described in detail in Simons et al. 2014 [30]. In short, we used a standardized measurement protocol to measure body weight, height, waist and hip circumferences and skinfold thickness (in the triceps, biceps, subscapular, and suprailiac regions) at T_0, T_{4m}, and T_{10m}. BMI (kg/m^2) was calculated by dividing the weight (kg) by the height squared (m^2). Next, the BMI-SDS was determined using the data from the fourth Dutch growth study among children in 1997 as a reference [1] and employing the Growth Analyser software [36]. Regarding the waist circumference we also determined the SDS values using the same reference group and software employed for the BMI values. Regarding the hip circumference and skinfold thickness, valid Dutch reference data were not available for the calculations of SDS scores.

Self-reported measures

The questionnaires assessed demographics (i.e., birth date, sex, educational level (pre-vocational, higher continued education, or pre-university) and country of birth (to define ethnicity according the definition of Statistics Netherlands [37]). Furthermore, active and non-active gaming behaviors, other screen and physical activities, snack and sugar-sweetened beverage intakes, video game consoles/application owned and video game companions were assessed with questionnaires. Among the adolescents in the intervention group, a process evaluation was conducted by adding several process evaluation questions to the questionnaires that were administered at T_{1m}, T_{4m}, and T_{10m}. Furthermore, the adolescents in the intervention group were asked to provide daily reports on their use of the Move video games over the entire ten-month period on a calendar. All of these self-reported measures are described in detail in Simons et al. [30]. We provide a summary of these measures below.

Time spent active and non-active gaming (T_0, T_{1m}, T_{4m}, T_{10m})

Questionnaires administered at T_0, T_{1m}, T_{4m}, and T_{10m} assessed the total hours per week that were spent on active and non-active video games by asking about gaming frequencies and durations separately for week and weekend days.

Physical activity and sedentary screen time (T_0, T_{1m}, T_{4m}, T_{10m})

To assess physical activity, we used the validated (correlation with CSA: r=0.48 - 0.78) Flemish Physical Activity Computerized Questionnaire (FPACQ) [38] and focused on the subdomains of active transport, leisure time walking and cycling and sports participation. The times spent in active transport, leisure time walking and cycling and sports participation were summed into a total physical activity score (hours per week).

To assess sedentary screen time, we used the questions about computer time and TV time from the FPACQ [38]. Both the computer and TV time were assessed separately for the week and weekend days and were then combined into total hours per week.

Consumption of snacks and sugar-sweetened beverages (T_0, T_{1m}, T_{4m}, T_{10m})

Consumption of sugar-sweetened beverages was assessed based on the methods of Van der Horst et al. [39], which involve questions about the frequency and amount (numbers of glasses, cans and bottles) of carbonated and non-carbonated soft drinks, lemonade, and sports and energy drinks consumed on a typical day. Diet sodas and juices were not assessed. The total consumptions of sugar-sweetened beverages are expressed in milliliters per week.

The consumption of snacks was assessed using the appropriate items from a validated questionnaire [39,40]. Snacks were classified as savory (e.g., fast-food, pizza, fries, chips, and nuts) or sweet (e.g., candy, candy bars, chocolate, cake, and biscuits) foods eaten between the main meals and not as side servings at main meals. The quantity of consumed snacks was obtained by determining the number of 'snack days' and the amount of snacks consumed per 'snack day'. These questions were combined into a single score to quantify the per-week snack intake.

Game consoles and applications owned (T_0, T_{1m}, T_{4m}, T_{10m})

At all measurements time points, we assessed the game consoles and game applications that the adolescents had access to in their homes to determine whether any participants in the control group purchased any active video game devices.

Process evaluation measures

A comprehensive process evaluation was conducted in the intervention group at T_{1m}, T_{4m} and T_{10m}. Findings from focus groups [22] and a survey about active and non-active gaming in adolescents [12] provided rationales for evaluating the following six elements: 1) adherence to the intervention (usage of the Move video games and reasons

for not playing at least one hour per week), 2) appreciation of the Move video games and the intervention (enjoyment, most played Move video game, most enjoying Move video game, ease of use, perceived competence, perceived physical exertion of playing Move video games, opinion about the number of provided Move video games, and self-purchase of Move video game), 3) game context (Move video game companions and location of the PlayStation Move console), 4) potential adverse effects (occurrence of injuries due to playing the Move video games), 5) activity replacement (the activities that were replaced by playing Move video games), and 6) intention to continue playing the Move video games.

In addition to the questionnaires, the adolescents in the intervention group reported the time that they spent playing the Move video games on a daily basis over the entire 10-month period in a calendar format. The adolescents were asked to report the type of Move video game and the number of hours and minutes spent playing the Move video games (cf. Chinapaw et al., 2008 [41]).

Statistical analyses

The analyses were performed according the pre-defined analyses plan described in Simons et al. [30]. First, descriptive analyses were performed, and the data were examined for normal distributions. We report the medians and interquartile ranges of variables that were not normally distributed and the means and standard deviations of variable that were normally distributed. Total sedentary screen time was log transformed due to the non-normal distribution of this variable. The consumption of sugar-sweetened beverages was dichotomized into more or less than 1400 ml per week. The cut off value of 1400 ml per week was based on the recommendation of the Netherlands Nutrition Centre that no more than one sugar-sweetened beverage per day should be consumed [42] (one glass is approximately 200 ml x 7 days = 1400 ml per week). Subsequently, the control and intervention groups were described in terms of baseline demographics and outcome measures. Moreover, we analyzed whether there were any differences between the persons with complete outcome data and the persons with one or more missing data points at follow-up by performing Fischer's exact, chi-square and t-tests separately for the anthropometric and questionnaire outcomes. Next, the effects of the intervention on all outcomes were evaluated by multilevel analyses with a random intercept on the person level. These models included the outcomes at one (only for the questionnaire outcomes), four and ten months and adjustments for the baseline values of the outcomes. For the continuous outcomes (i.e., BMI-SDS, waist circumference-SDS, hip circumference, skin fold thickness, non-active video game time, total sedentary screen time, physical activity and consumption of snacks), we used linear mixed models, whereas for the dichotomous outcomes (i.e., active video game time and consumption of sugar-sweetened beverages), we used logistic mixed models. In the main analyses, we analyzed the data from participants with at least a baseline value and one follow-up measurement. Ten persons had missing anthropometric data

at follow-up, and eight persons had missing baseline questionnaire data; thus these persons could not be included in the main analyses. As sensitivity analyses for potential selection bias, we also imputed the first follow-up measurements for persons with only baseline anthropometric measurements (n=10) and the baseline measurement for persons with missing baseline questionnaire data (n=8) using multiple imputation with chained equations (true intention to treat). In the datasets with these imputed values (10 for the anthropometrics data and 8 for the questionnaire data), we then used the same mixed models. In addition to the model that was adjusted for baseline (model 1), we also constructed a second model that was additionally adjusted for demographics (age, sex, ethnicity and adolescent educational level) [1, 10, 43] (model 2).

Additionally, a group * time interaction was added to estimate the time-specific intervention effects. In the results section, only the fully adjusted models (model 2) are reported in the text. Model 1 is included in the tables as background information. Second, analyses were performed according to the per-protocol principle. Adherence to the protocol was separately defined for each follow-up measurement, based on the reported Move video game time in the questionnaire. The intervention group adolescents who played the Move video games at least one hour per week were allocated a score of 1 for adherence, and the intervention group adolescents who played less than one hour per week and the control group adolescents were scored 0. Again, two models were constructed for each outcome measure (with the exception of active video gaming) and were adjusted for the same variables as in the main analysis. Finally, descriptive statistics were used for the process evaluation measures and the use of the Move video games over the ten-month-intervention period based on the Move video game calendar.

Multiple imputation with chained equations and analyses of the imputed data were performed using STATA. Other statistical analyses were performed using IBM SPSS Statistics version 21 with a statistical significance level of $p<0.05$ for detecting main intervention effects.

Results

Participants

In total, 270 adolescents completed the anthropometric baseline measures and were randomly allocated to the intervention or control group. Of these 270 randomized adolescents, 260 participated in at least one of the anthropometric follow-up measurements and were included in the main analyses of the primary outcomes (anthropometrics). Two hundred sixty-two adolescents completed the baseline and at least one follow-up questionnaire and were included in the main analyses based on the questionnaire data (Figure 1). Missing data analyses revealed that the adolescents who missed one or more

anthropometric measurements (n=30) did not differ in age (T(268): -1.296; P=0.19), sex (Fisher's exact P=0.51), educational level (Fisher's exact P=0.392) or ethnicity (Fisher's exact P=0.620) from the adolescents with complete anthropometric data (n=240). Further, the adolescents who missed one or more questionnaire measurement (n=42) did not differ in age (T(268): -1.235; P=0.218), sex (Fisher's exact P=1.0), educational level (Fisher's exact P=0.064) or ethnicity (Fisher's exact P=0.074) from the adolescents with complete questionnaire data (n=228).

Table 1 shows the baseline characteristics of the adolescents. The mean age was 13.9 (SD=1.3) years, the majorities were boys, engaged in higher levels of secondary education, and of Dutch ethnicity, and approximately 1/4 were overweight or obese according the international cut off value of Cole et al., 2000 [44].

Table 1: Baseline characteristics of adolescent study participants (mean (SD) or %)

	Intervention group	Control group	Total
Demographics	**N=134**	**N=126**	**N=260**
Age, mean (SD)	13.7 (1.3)	14.1 (1.3)	13.9 (1.3)
Sex, % boys	90	92	91
Educational level, % Attending higher educational level[a]	72	65	69
Ethnicity, % Dutch origin[b]	85	80	83
Anthropometrics			
BMI	20.6 (3.7)	20.3 (3.0)	20.5 (3.4)
BMI-SDS[c]	0.48 (1.2)	0.35 (1.1)	0.42 (1.1)
% Overweight/obese[d]	25	19	22
SDS-waist circumference[c]	0.53 (1.07)	0.36 (0.98)	0.45 (1.03)
Hip circumference	88.4 (8.4)	87.9 (7.7)	88.2 (8.04)
Sum of skin folds	52.1 (31.3)	50.0 (26.5)	51.1 (29.01)
Behaviour	**N=138**	**N=124**	**N=262**
Active gaming • % ≥ 1 hour per week	21	29	25
Non-active gaming • Median (IQR)	12.0 (11.0)	9.58 (10.81)	11.0 (10.7)

	Intervention group	Control group	Total
Total sedentary screen time • Median (IQR)	39.25 (28.0)	36.33 (20.98)	37.42 (24.23)
Physical activity[e] • Median (IQR)	10.63 (7.02)	10.38 (6.42)	10.5 (7.0)
Snack intake • Median (IQR)	10.0 (12.25)	12.0 (13.0)	11.5 (13.0)
Consumption of sugar-sweetened beverages • % >1400 ml/week	73	76	74

[a]Higher educational level= higher continued education and Pre-university education (low educational level= pre-vocational education)
[b]Adolescents were defined as Dutch origin when both parents were born in the Netherlands [37].
[c]SDS scores were calculated with the use of data from 1997 described by Schönbeck et al., 2011 [1]
[d]Based on international cut-off points for overweight and obesity [44]
[e]Sum of active transport to school, walking and cycling for transport in leisure time and sports participation
IQR = Interquartile Range

Effects on anthropometric parameters

Table 2 presents the descriptive information for all of the anthropometric outcomes at baseline, T_{4m}, and T_{10m} for the intervention and control group and the results of the main multilevel analyses. In the fully adjusted analyses (model 2), we observed significant intervention effects in the unintended direction at T10m and overall for BMI-SDS and the sum of the skin folds. Regarding hip circumference, we found a time x group interaction effect (P=0.015); there was no significant difference at T_{4m}, but at T_{10m}, hip circumference was significantly higher in the intervention group than in the control group. We observed no significant intervention effects on waist circumference-SDS in the fully adjusted models. The sensitivity analyses on the imputed data produced very similar results (not reported here).

The per-protocol analyses revealed no significant overall effects of adherence to the protocol (i.e., playing the Move video games for at least one hour per week) on BMI-SDS (Model 1: ß = 0.048, 95% confidence Interval (CI): -0.029 to 0.126; Model 2: ß = -0.05, 95% CI: -0.186 to 0.084), waist circumference-SDS (Model 1: B= 0.0896, 95% CI: -0.012 to 0.192; Model 2: ß =0.085, 95% CI: -0.0146 to 0.185), or hip circumference (Model 1: ß = 0.042, 95% CI: -0.577 to 0.662; Model 2: ß = 0.0089, 95% CI: -0.608 to 0.625) and a significant effect in the unintended direction on the sum of the skinfolds (Model 1: ß = 3.28, 95% CI: 0.211 to 6.355; Model 2: ß = 3.11, 95% CI: 0.04 to 6.18).

Effects on behaviours

Table 3 presents the descriptive information about the behavioral outcomes at baseline, T_{1m}, T_{4m}, and T_{10m} for the intervention and control groups and the results of the multilevel analyses. Based on the fully adjusted models (model 2), the intervention group was more likely to play active video games for at least one hour per week. Regarding active video gaming we observed a time x group interaction effect (P=0.015) in which the effect diminished over time (Table 3). Further, the intervention had a beneficial overall effect on the time spent playing non-active video games in favor of the intervention group. Additionally, overall, the intervention group exhibited a 0.8 fold reduction in the geometric mean of sedentary screen time (i.e., TV/DVD, non-active video games, and computer time combined) compared to the control group (Table 3). Regarding the consumption of sugar-sweetened beverages, total physical activity and the consumption of snacks, we found no significant differences based on the fully adjusted model (model 2). The sensitivity analyses on the imputed data produced very similar results (not reported here).

The per-protocol analyses revealed no significant overall effects of adherence to the protocol (i.e., playing the Move video games for at least one hour per week) on non-active gaming (Model 1: ß=-0.34, 95% CI: 0-1.78 to 1.09; Model 2: ß= -0.09, 95% CI: -1.52 to 1.34), total sedentary screen time (Model 1: Exp (ß) (ratio of geometrical mean) = 0.94, 95% CI: 0.87 to 1.03; Model 2: Exp (ß)= 0.96, 95% CI: 0.88 to 1.05), physical activity (Model 1: ß = -0.28 95% CI: -1.11 to 0.55; Model 2: ß= -0.29, 95% CI: -1.11 to 0.53), consumption of sugar-sweetened beverages (Model 1: OR= 1.1, 95% CI: 0.68 to 1.79; Model 2: OR = 1.36, 95% CI: 0.82 to 2.27), or consumption of snacks (Model 1: ß= -0.15, 95% CI: -1.65 to 1.35; Model 2: ß= -0.11, 95% CI: -1.62 to 1.41).

Table 2: Results of main multilevel regression analyses (ß (95% CI)) to evaluate the effects of the active game intervention on anthropometrics after 4 and 10 months (statistical significant ß with their 95%CI's are printed in bold).

		Intervention group		Control group	Model 1[b]	Model 2[c]
	N	Mean (SD)	N	Mean (SD)	ß (95%CI)	ß (95%CI)
BMI-SDS[a]						
Baseline	134	0.48 (1.2)	126	0.35 (1.1)		
4-months	123	0.51 (1.2)	120	0.33 (1.0)	0.044 (-0.035; 0.123)	0.049 (-0.031;0.128)
10-months	131	0.49 (1.1)	126	0.28 (1.0)	0.093 (0.015; 0.17)	0.098 (0.0199;0.176)

		Intervention group		Control group	Model 1[b]	Model 2[c]
	N	**Mean (SD)**	**N**	**Mean (SD)**	**ß (95%CI)**	**ß (95%CI)**
Overall effects					0.069 (0.003;0.135)	0.074 (0.008;0.14)
SDS-waist circumference[a]						
Baseline	134	0.53 (1.07)	126	0.36 (0.98)		
4-months	123	0.61 (1.04)	120	0.45 (1.0)	0.05 (-0.246;0.347)	0.025 (-0.271;0.321)
10-months	131	0.63 (1.05)	126	0.37 (0.98)	0.258 (0.010;0.506)	0.23 (-0.017;0.476)
Overall effects					0.045 (-0.043;0.132)	0.039 (-0.046;0.125)
Hip circumference (cm)						
Baseline	134	88.4 (8.4)	126	87.9 (7.7)		
4-months	123	89.3 (8.0)	120	89.1 (7.4)	0.025 (-0.615;0.665)	0.004 (-0.645;0.653)
10-months	131	89.8 (7.9)	126	88.5 (6.9)	0.823 (0.196;1,451)	0.751 (0.113;1.39)
Overall effects					0.44 (-0.121;1.00)	0.39 (-0.18;0.964)
Sum of skin folds (mm)						
Baseline	134	52.1 (31.3)	126	50.0 (26.5)		
4-months	123	51.1 (28.9)	120	46.5 (24.5)	2.27 (-2.94;7.48)	2.50 (-2.75;7.76)
10-months	131	50.0 (31.6)	126	44.7 (23.7)	3.42 (0.227;6.609)	3.45 (0.196;6.71)
Overall effects					3.13 (0.246;6.019)	3.22 (0.266;6.17)

[a]SDS-BMI – standard deviation of body mass index; SDS-waist circumference – standard deviation of waist circumference.
[b]Model 1 adjusted for baseline outcome value;
[c]Model 2 adjusted for baseline outcome value, age, sex, ethnicity and adolescent educational level.
Control group = 0; Intervention group =1 (ref)

Table 3: Results of intention to treat multilevel regression analysis (ß (95% CI)) to evaluate the effects of the active game intervention on game behaviour, sedentary screen time, physical activity and energy intake after 1, 4 and 10 months (statistical significant ß with their 95%CI's are printed in bold).

		Interven-tion group		Control group	Model 1[a]	Model 2[b]
	N		**N**			
Active game time (>1 hours per week) (yes=1; no=0)		***% >1 hours per week***		***% >1 hours per week***	***OR (95%CI)***	***OR (95%CI)***
Baseline	138	21	124	29		
1-month	131	94	111	23	133.98 (48.25; 372.06)	126.79 (44.59; 360.56)
4-months	130	85	119	20	54.94 (23.03; 131.05)	57.52 (23.38; 141.5)
10-months	131	78	121	22	27.33 (12.21;61.16)	29.34 (12.70; 67.75)
Overall effect					48.3 (26.84; 86.95)	49.47 (26.8; 91.29)
Non-active game time (hours per week)		***Median (IQR)***		***Median (IQR)***	***ß (95%CI)***	***ß (95%CI)***
Baseline	138	12.0 (11.0)	124	9.58 (10.81)		
1-month	131	8.7 (9.0)	111	10.7 (9.0)	-1.9 (-3.72;-0.089)	-1.49 (-3.33;0.35)
4-months	130	6.6 (7.6)	119	9.0 (7.5)	-1.78 (-3.58;0.018)	-1.33 (-3.15;0.48)
10-months	131	6.8 (6.0)	121	8.3 (9.8)	-2.94 (-4.74;-1.15)	-2.49 (-4.31;-0.67)
Overall effect					-2.2 (-3.63;-0.78)	-1.76 (-3.20; -0.32)

		Interven-tion group		Control group	Model 1[a]	Model 2[b]
	N		**N**			
Total sedentary screen time (hours per week)[c]		***Median (IQR)***		***Median (IQR)***	***Exp (ß) (95%CI)[e]***	***Exp (ß) (95%CI)[e]***
Baseline	138	39.25 (28.0)	122	36.33 (20.98)		
1-month	130	31.5 (25.35)	110	38.71 (23.58)	0.78 (0.70;0.86)	0.82 (0.73;0.91)
4-months	129	29.0 (19.88)	119	35.0 (23.22)	0.82 (0.74;0.90)	0.78 (0.69;0.87)
10-months	131	30.5 (22.0)	121	34.83 (23.70)	0.79 (0.72;0.88)	0.82 (0.74;0.92)
Overall effect					0.80 (0.72; 0.86)	0.81 (0.74; 0.88)
Physical activity[d] (hours per week)		***Median (IQR)***		***Median (IQR)***	***ß (95%CI)***	***ß (95%CI)***
Baseline	138	10.63 (7.02)	124	10.38 (6.42)		
1-month	131	10.17 (6.17)	111	10.36 (6.33)	-0.24 (-1.34;0.86)	-0.40 (-1.53;0.73)
4-months	130	10.25 (5.92)	119	10.25 (6.33)	-0.05 (-1.15;1.04)	-0.56 (-1.72;0.59)
10-months	131	10.0 (6.17)	121	10.0 (6.96)	-0.08 (-1.17;1.01)	-0.37 (-1.5;0.77)
Overall effect					-0.12 (-1.04;0.80)	-0.43 (-1.34;0.48)
Consumption of sugar-sweetened beverages (>1400 ml per week (yes=1; no=0)		***% >1400 ml/week***		***% >1400 ml/week***	***OR (95%CI)***	***OR (95%CI)***
Baseline	138	73	124	76		
1-month	131	61	111	78	0.50 (0.25;0.98)	0.49 (0.24;1.01)
4-months	130	60	119	71	0.69 (0.36;1.33)	0.74 (0.38;1.47)
10-months	131	62	121	77	0.67 (0.34;1.29)	0.71 (0.36;1.41)
Overall effect					0.62 (0.40; 0.96)	0.65 (0.41;1.03)

		Interven-tion group		Control group	Model 1[a]	Model 2[b]
	N		**N**			
Consumption of snacks (pieces/ portions per week)		***Median (IQR)***		***Median (IQR)***		
Baseline	138	10.0 (12.25)	124	12.0 (13.0)		
1-month	131	10.0 (11.0)	111	11.0 (11.0)	-1.44 (-3.38;0.50)	-0.98 (-3.03;1.07)
4-months	130	9.0 (9.0)	119	10.0 (12.0)	-0.72 (-2.64;1.20)	-1.76 (-3.86;0.33)
10-months	131	9.0 (11.0)	121	11.0 (10.5)	-1.11 (-3.03;0.82)	-0.87 (-2.93;1.18)
Overall effect					-1.07 (-2.66;0.50)	-1.12 (-2.75;0.50)

Control group = 0 (reference group); Intervention group =1

[a]Model 1 adjusted for baseline outcome value;

[b]Model 2 adjusted for baseline outcome value, age, sex, ethnicity and adolescent educational level.

[c]Total sedentary screen time includes TV/DVD, non-active game and computer time

[d]Physical activity includes sports, active transport to school and walking and cycling in leisure time.

[e]Value represents Exp (ß) (95%CI) which is the ratio of geometrical means

IQR= Interquartile Range

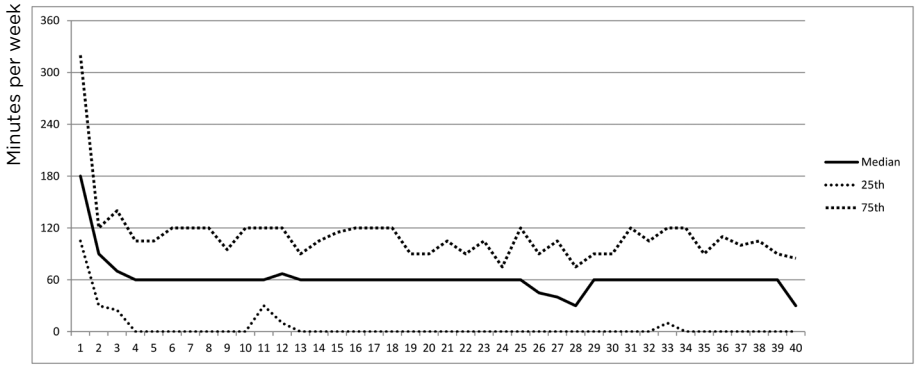


Figure 2: Development of usage of the Move games (minutes per week) over the 10-month (40 weeks) intervention period.

Process evaluation

Table 4 shows the results of the process evaluation. At T_{1m}, slightly more than half of the adolescents in the intervention group reported playing the Move video games for at least one hour per week, and after ten months, this proportion was approximately one-third. Across the entire intervention period, 14% of the adolescents reported playing the Move video games every week for at least one hour per week at all the time points.

Figure 2 shows the development of time spent playing the Move video games (minutes per week) over the 40-week-intervention period based on the Move game calendars. After a peak in the first week, the median declined to approximately 60 minutes per week. From week 4 onwards, the 25th percentile was generally on the null line, indicating that at least 25% of the participants did not play the Move games at all during most of the intervention period. The adolescents who did not always play the Move video games for the minimum of one hour per week (N=50) indicated that a lack of time or too many other things to do were the main reasons for not meeting this minimum. 'I Rather played non-active video games' was increasingly mentioned a reason during the course of the intervention. Further, the adolescents increasingly reported that the Move video games were boring.

The mean enjoyment score was moderately positive and exhibited a decreasing trend over the intervention period. The participants thought that the Move video games were easy to handle based on the Ease of Use scores. Furthermore, the participants thought that they were moderately competent in playing the Move video games. The most-often played and most enjoyed Move video games were DanceStar Party and Start the Party: Save the World. The least played Move video game was Sports Champions. Most of the adolescents were satisfied with the number of Move video games provided. Further, approximately 1/4 of the adolescents bought extra Move video games themselves (e.g.

Killzone 3, FIFA 13, Just Dance, Little Big Planet 2, Virtua Tennis 4, and Top Spin). Further, the majority of the adolescents perceived playing the Move video games to be a moderate-intense activity. Regarding game context, the majority of the adolescents played the Move video games alone, and most placed the PlayStation Move in the living room or in their own bedroom.

At T_{10m}, 1/5 of the intervention group reported having experienced an injury (the most frequently mentioned injuries were bruises or strained muscles/tendons) while playing the Move video games. The majority of the adolescents reported that the Move video games primarily replaced non-active video games. Finally, nearly half of the adolescents intended to continue playing with the Move video games.

One adolescent in the control group reported having a PlayStation Move at baseline but not during the follow-up measurements. At T_{10m} one additional adolescent in the control group reported having a PlayStation Move application.

Table 4: Process evaluation outcome measures at 1 month, 4 months and 10 months.

	1 month	4 months	10 months
1. Adherence to intervention			
How much time did you spend on average playing the Move games? (% (n))			
• 0-60 minutes per week	42 (54)	60 (79)	67 (87)
• 60 minutes or more per week	58 (74)	40 (51)	33 (44)
Did you succeed in playing the move games for at least one hour per week?			
• Yes, I played the move games for at least one hour per week	61 (79)	33 (43)	28 (37)
• No, in some weeks I failed to play the move games for at least one hour	37 (48)	58 (77)	55 (73)
• No, I never succeed in playing the move games for at least one hour per week	2 (3)	9 (12)	17 (22)
Reasons for not playing the Move games among adolescents who did not succeed to play ≥ 1 hour per week Move games (top 5) (% (N)):			
• Lack of time	64 (32)	67 (59)	71 (67)
• Too many other things to do	56 (28)	66 (58)	65 (61)
• Rather playing non-active video games	24 (12)	42 (37)	50 (47)
• Move games were boring	18 (9)	30 (26)	37 (35)
• Lack of space to play the Move games	22 (11)	18 (16)	16 (15)

	1 month	4 months	10 months
2. Appreciation of the Move games and the intervention			
Enjoyment (scale 1-7) (mean (SD)	4.8 (1.2)	4.0 (1.4)	3.7 (1.5)
Ease of use (scale 1-5) (mean (SD)	4.4 (0.7)	4.4 (0.7)	4.3 (0.7)
Competence (scale 1-5) (mean (SD)	3.7 (0.6)	3.6 (0.6)	3.5 (0.7)
Most often played Move game (based on a rank score from 1 to 6) (mean (SD)			
• Dance start Party	-	-	4.2 (1.7)
• Start the Party: Save the World	-	-	4.2 (1.7)
• Sorcery	-	-	3.7 (1.7)
• Move Fitness	-	-	3.5 (1.5)
• Medieval Moves	-	-	3.3 (1.3)
• Sports Champions	-	-	2.1 (1.4)
Most enjoyed Move games (based on the mean rank score (1 to 6) (Mean (SD)			
• Start the Party: Save the World	-	-	4.1 (1.7)
• DanceStar Party	-	-	4.1 (1.7)
• Sorcey	-	-	3.6 (1.8)
• Move Fitness	-	-	3.6 (1.5)
• Medieval Moves	-	-	3.5 (1.4)
• Sports Champions	-	-	2.2 (1.4)
Opinion on the amount of provided Move games (% (n))			
• Too little	-	-	21 (27)
• Good	-	-	74 (98)
• Too much	-	-	5 (6)
Did you bought, received, borrowed or downloaded other Move games in addition to the games we provided you?			
% (N) yes	-	-	26 (34)
Perceived physical exertion of playing Move games (% (n))			
• Light	-	-	37 (49)
• Moderate	-	-	58 (75)
• Heavy	-	-	5 (7)
3. Game context			
Move game companion (% (n))			
• Alone	-	-	58 (77)
• With friends	-	-	21 (27)
• With brother/sister	-	-	16 (21)
• With others	-	-	3 (4)
• With my parents	-	-	2 (2)

	1 month	4 months	10 months
Location of PlayStation Move console			
• Living room	-	-	42 (55)
• Adolescent's bed room	-	-	42 (55)
• Brother/sister's bedroom	-	-	6 (8)
• Attic	-	-	5 (7)
• Shared game/computer room	-	-	5 (6)
4. Potential adverse effects			
Injuries (bruises or strained muscles/tendons) during playing Move games (% (N))	-	-	20% (26)
5. Activity replacement			
Playing Move games mainly replaced			
• Playing non-active game	-	-	65 (85)
• Watching TV	-	-	11 (14)
• Surfing the web	-	-	8 (11)
• Sports	-	-	4 (5)
• Playing outside	-	-	2 (2)
• Other ...	-	-	10 (14)
6. Intention to continue playing the Move games			
I intend to continue playing the Move games. (% (N) agree or totally agree)	-	-	44 (57)
I expect to continue with playing the Move games (totally disagree (% (N) probably or very probably)	-	-	49 (64)

Discussion and conclusion

The aim of the current study was to evaluate whether providing active video games could prevent unnecessary increases in anthropometrics among gaming adolescents who were primarily of healthy weight. The findings regarding the anthropometrics revealed that the active video game intervention had no effects in favor of the intervention group and even some effects in the unexpected direction were observed. The intervention group remained relatively stable regarding most of the anthropometric outcomes over time, and the control group improved somewhat in terms of their anthropometric outcomes. Furthermore, some beneficial effects on self-reported non-active gaming and total sedentary screen time (i.e., watching TV/DVD, computer time and non-active gaming combined) were found in favor of the intervention group. We found that the intervention had no effects, either positive or negative, on the levels of self-reported physical activity or the intakes of sugar-sweetened beverages and snacks. Compliance with the intervention was very low, although the adolescents in the intervention group were significantly more likely to play the active video games for at least one hour per week than the adolescents in the control group (OR=49). It is important

to acknowledge that the ORs for active gaming (and also for the consumption of sugar-sweetened beverages) should not be interpreted as risk ratios due to the high proportion of the sample who reported that they engaged in active gaming for at least one hour per week (or consumed >1400 ml/week sugar-sweetened beverages) at each time point.

Unexpectedly, the control group exhibited improvements in BMI-SDS, while the intervention group generally remained stable. The process evaluation did not provide any reason to believe that the adolescents in the control group bought Move packages themselves and began playing (more) active video games. Further, no evidence was found that indicated meaningful differences in life style behaviors between the intervention and control group.. Although the intervention aimed to enable and motivate the participants to engage in active video gaming, only 14% of the participants in the intervention group managed to play for at least one hour per week throughout the intervention period. The dose of active video game play might thus have been insufficient to induce differences in the anthropometrics between the intervention and the control group. A second reason for the lack of an effect on the BMI-SDS of the intervention group might be that our study focused on a general group of gaming adolescents who primarily were of healthy weight. In accordance with our study's purpose –i.e., to evaluate the role of active gaming in the primary prevention of overweight and obesity in youth– we therefore did not select a high-risk group such as adolescents who were already overweight or obese. Earlier studies that focused on overweight children, and thus more on the 'treatment' of overweight, have reported beneficial effects on BMI and/or body composition [26,27,29]. These findings suggest that active video games might be more effective in higher-risk populations such as overweight adolescents. A third reason for the lack of effects might be that our intervention aimed to replace non-active gaming with active gaming and thus attempted to change non-active video gamers into active video gamers. Therefore, we recruited adolescents who spend substantial amounts of time on non-active gaming. At baseline, our participants spent on average almost 14 hours per week playing non-active games. Based on other time expenditure studies in Dutch adolescents [12,45], our participants can be considered excessive non-active video gamers, which likely made it even more difficult to motivate them to become active video gamers. Further, it should be noted that our participants can not be described as inactive because the median physical activity was 10.5 hours per week. It could be that a more inactive group might be more susceptible for active games. The current results also indicate that the current commercially available active video games cannot (yet) truly compete with non-active video games because the intervention group participants told us that they preferred playing non-active video games and thought that the active video games were boring. This finding accords with those of our previous studies that indicated that turning non-active video gamers into active video gamer might be difficult to achieve [12, 22].

Other differences between our study and earlier studies that did find beneficial effects were included the targeting younger children (8-14 years) [27,29], the use of school setting [26] and the incorporation of active video games into a larger weight management program [29] in the earlier studies. Furthermore, all of the previous studies utilized shorter intervention and follow-up periods. Younger children (8-12) might be more receptive to active video games. Focus groups among 8 to 12 year-olds showed have indicated that these younger children are less critical about active video games and even prefer active video games above non-active video games [46]. Future studies should evaluate which strategies can increase sustainable active video game play and whether other target groups (e.g., younger children) are more suitable for active video game interventions.

These potential reasons for the lack of effects in the intervention group do not however explain the observation that the control group exhibited anthropometric improvements while the intervention group remained stable. Moreover, it is remarkable that the self-reported sedentary screen time of the intervention group was less than that of the control group, which might be related to social desirability bias (see limitations below).

During recruitment, we communicated that all participants would receive the Move video games (either at the start of the study or after ten months). Therefore, at the end of the study, the control group also received the active video games. If we had known the study results in advance, we would not have provided the active video games to the control group. Nevertheless, based on the intervention effects we observed (i.e., the anthropometrics data from the intervention group remained relatively stable over time and their self-reported sedentary screen time decreased over time), we do not believe that providing the active video games to the control group would have been harmful.

Limitation and strengths

The limitations of the current study are the self-reported secondary outcome measures and their susceptibility to social desirability and recall biases. Furthermore, the active video game questionnaires and calendars were not checked for validity. The intervention group might have provided more socially desirable answers than the control group because, as part of the intervention, the participants in the intervention group were asked to replace non-active gaming with active gaming. Unfortunately, we could not use objective data to monitor physical activity and game behavior. Video game play data are stored in the game consoles, but due to privacy regulations these data could not be obtained.

The measured anthropometrics are clear strengths of the present study. In our analyses, we used BMI-SDS scores that were based on an external reference (i.e., the population level growth data [1]) as recommended by Must and Anderson (2006) [47]. BMI-SDS values provide insight into how a participant's BMI is related to other individuals of the same age and sex within the general Dutch population. In other words, the BMI-SDS

indicates the extent to which an individual's BMI value deviates from 'normal' and is easier to interpret than crude BMI; therefore BMI-SDS values are used by most pediatricians in The Netherlands. Other strengths include the large number of participants, the low attrition and thus power of the study, the long intervention period, and the comprehensive process evaluation that provided valuable additional insights and information for the interpretations of the results.

Recommendations for future research

Thus far, the evidence relating to the use of active video games as a weight management tool for overweight or obese children is mixed, and evidence for active gaming as a means to prevent excessive weight gain in normal-weight children is still lacking after the present study. Given the popularity of video gaming among youth, further high-quality research is needed regarding on how, when and among whom active video gaming can be effectively applied to promote health and prevent weight gain. Based on findings from earlier studies on the treatment of overweight and obesity, the integrating of active video games into broader health promotion programs seems most promising. Therefore, future studies should examine this issue further and focus on, for example, how to combine and target multiple settings, such as the home, school, and neighborhood, and examine the effectiveness of such integral multi-setting programs in the long-term. When evaluating active video game interventions, we recommend to use objective measurements (e.g. accelerometry) in combination with self-reports for assessing physical activity and sedentary behavior. Regarding assessing video gaming behavior, preferably the data that are electronically registered in the consoles should be used because this process would avoid participant burden and overcome the problems of under or over reporting and the providing of socially desirable answers. Therefore, it is important that the game industry make the stored game data available for research purposes. Also we recommend the use of objective measures of physical activity (e.g. accelerometry) in combination with self-report.

The process evaluation results indicated that there is a need for a new generation of active video games that are better able to compete with non-active games in terms of fun, attractiveness, persuasiveness and sustainability. Thus far, the majority of studies have focused on commercially available active games for consoles such as the Xbox 360 Kinect, PlayStation 3 Move and Nintendo Wii. In addition to these console-based active video games, one could also think of more mobile games on platforms such as smartphones or tablets. These platforms are suitable for the utilization of using technologies such as the Global Positioning System (GPS) and augmented reality, which could increase the possibilities for physical activity in and beyond the game. Furthermore, the focus of research should not be limited to only active video games that are developed by the commercial entertainment game industry (as in this trial), whose main goal is to sell as many devices and video games as possible. Rather, future studies should also focus on active video games, such as the active game Olympus [48], that are based on

behavioral theories and developed by serious game designers whose main goal is to promote physical activity. Furthermore, it is important that future studies also focus on the potentially undesirable effects of active video game interventions, such as reduced levels of prosocial behavior and life satisfaction and neglect of school responsibilities, because some studies have observed such effects to be associated with non-active video game play [49,50].

Conclusion

Despite the finding that self-reported sedentary screen time was reduced, the current study suggests that providing active video games to a group of excessive non-active video gamers in their home environment is not effective and might even be counter-effective in altering anthropometrics. In conclusion, the present active video game intervention is not a suitable tool for the prevention of excessive weight gain among gaming adolescents.

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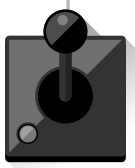
CHAPTER 8

General discussion



Aims

The overall aim of this thesis was to examine whether providing active games in a home setting can contribute to the prevention of unnecessary weight gain in gaming adolescents. The first part of this thesis focuses on analyzing the gaming behavior of adolescents by evaluating, the amount of time spend on active and non-active gaming and demographic variables associated with gaming. Further, it was explored how time spend in active gaming was associated with other energy balance-related behaviors. The second part evaluated the determinants of active and non-active gaming. Finally, in part 3 a randomized controlled trial was conducted among gaming adolescents who were mainly of healthy body weight to evaluate the effects of providing active games in their homes.

In this chapter the main findings will be summarized and critically evaluated. In addition, methodological considerations will be discussed. Next, the findings will be placed in a broader perspective analyzing if and how games can contribute to promoting health related behaviors in order to prevent overweight. This will lead to recommendations for practice and future research.

Main findings

In part 1, *Analysis of gaming behavior*, the survey showed (chapter 2) that the large majority of Dutch adolescents (83%) play video games, either active or non-active versions. Almost half of the respondents reported to play active games, especially those attending lower educational school levels, and most of them played active games in combination with non-active games. Sex and age were not associated with active gaming (≥1 h/wk) in adolescents, while findings showed that boys and older adolescents were more likely to play non-active games (>7 h/week) than girls and younger adolescents. The amount of time spend on active gaming was relatively low compared to that spend on non-active games: 36 min on a school day and 42 min on a weekend day for active gaming versus 65 min on a school day and 80 min on a weekend day for non-active gaming. Importantly, chapter 3 (24-hours-recall study) showed that playing active games is unlikely to be a substitute of (other) physical activities. Yet, spending more time playing active games was associated with a small, but statistically significant longer TV/DVD time and intake of snacks. Another interesting finding from chapter 3 was that adolescents, who reported to have played active games, reported longer non-active game time than those who reported not to have played active games.

In part 2, *Analysis of determinants of engaging in gaming behaviors,* the findings of the focus groups in adolescents are presented (chapter 4). Adolescents indicated they liked active games; nonetheless a substantial proportion of them preferred non-active games. They mentioned, for example, that active games were of inferior quality compared to

non-active games in terms of graphics, accuracy, functioning of controllers, and variety. Furthermore, adolescents mentioned they liked playing active games when friends or family were visiting them and they liked laughing at each other while playing the active games. Besides that, they liked the interactivity of the active games, i.e., controlling the game with their body movements. The survey described in chapter 5 showed that various personal, social and game-related factors were statistically significantly associated with active gaming ≥1 h/wk and that these factors were partly different than those for non-active gaming >7 h/wk. Regarding personal factors, a more negative attitude towards non-active games and a more positive attitude towards active games were associated with an increased likelihood of playing active games ≥1 h/wk. In addition, for non-active gaming, a more positive attitude towards non-active gaming and a more positive image of a non-active gamer were associated with non-active gaming >7 h/wk. Habit strength correlated with both active ≥1 h/wk and non-active gaming >7 h/wk. Concerning social factors, having brothers/sisters and friends who spend more time on active gaming was associated with playing active games ≥1 h/wk. Also for non-active gaming, having friends (but not brothers and sisters) who spend more time on non-active gaming, but also a more positive image of a non-active gamer were associated with non-active gaming >7 h/wk. Finally, concerning game-related factors we found that a lower score on game engagement was associated with playing active games ≥1 h/wk. We did not find any associations between game related factors and playing non-active games >7 h/wk.

In part 3, *Intervention development and evaluation*, chapter 6 described the content of the active game intervention and the study design to evaluate the intervention. The randomized controlled trial, presented in chapter 7, indicated that providing gaming adolescents with an active game and simultaneously promoting its use was ineffective in preventing unnecessary weight gain and even had some effects on anthropometrics in the unintended direction (i.e. in favor of the control group). The intervention did result in lower self-reported non-active game time and total sedentary screen time. No effects of the intervention were found on self-reported physical activity and consumption of sugar-sweetened beverages and snacks. The process evaluation showed that despite the intervention aiming to enable and motivate adolescents to engage in active gaming at least one hour per week, only 14% of the participants in the intervention group managed to do so. Frequently mentioned reasons for not playing the active games were lack of time, preferring to play non-active games, and the active games being experienced as boring.

Reflections on main findings

Many adolescents already play active games, but for a relatively low amount of time

In line with previous studies [1-4] our findings confirmed the pervasiveness and large dose of non-active game play among adolescents. The added value of our study

is the additional focus on active gaming; we showed that almost half of the adolescents already played active games, mostly in combination with non-active games. Time spent on active games was about half the time spent on non-active games, which is comparable to other studies [5;6]. Two other studies showed slightly lower rates of adolescent youth playing active games. A Dutch report showed that 39% of adolescents (aged 12 through 14 years) play active games at least once a week [5]. Next, a Canadian study found that 24% in 14-19 year olds had played active games at least once [7]. Three reasons could be given for the higher number found in our study compared to the other studies. First, our data were collected more recently and the higher number might indicate that active games gained popularity more recently. Second, the higher number in our study might be due to methodological differences in study populations or measures to assess active gaming. Third, it might be due to difference in reference period in assessing active gaming.

In summary, our results show – in line with other available research – that although many adolescents play active games, many more play non-active games and they spent far less time in playing active games than in non-active games. Thus, active games are theoretically a useful intervention tool and potentially reaching non-active gamers, because apparently many adolescents (including non-active gamers) are interested in it. On the other hand, our findings suggest that active games need further development before being able to compete with non-active games.

Active games seem to attract a wide range of adolescents and especially those attending lower educational school levels

Specific groups appeared to be attracted to and engaged in non-active and active gaming. Adolescents attending lower educational school levels were more likely to play active games regularly than adolescents attending higher educational levels. This suggests that active gaming is especially a promising tool for the adolescents attending relative low levels of education, who have most to gain by becoming more physical active, being less sedentary and weighing less [8;9]. Lower educated people are also difficult to reach with traditional health promotion messages [10;11]. Furthermore, the present findings suggest that active games are suitable for targeting both boys and girls, because sex was not associated with active gaming, in line with another Dutch study that found no sex differences for active gaming either [6)]. However, a Canadian study showed that adolescent girls (14-19 year old) were more likely to play active games than boys [7]. The inconsistent findings of these studies could be due to the difference in operationalization of active gaming (playing active games yes/no or playing active games $< / \geq 1$ hour/week), cultural differences (The Netherlands versus Canada) or differences in the participants' age range (12-16 versus 14-19 years old). For non-active gaming we found that boys were much more into playing than girls, which is a well-established finding in game literature [3;12;13]. Hence, boys seem the most relevant target group with active games, when the aim is to substitute non-active game time. On the other hand studies suggest that girls are equally (chapter 2) or even more interested in active game play [7].

Moreover, the lower levels of physical activity in girls compared to boys [14] and the barriers girls experience for sports participation [15], illustrate the importance for new activity promoting tools (such as active games) to reach girls.

With respect to age, although one past study in Dutch adolescents found that regular active gamers were slightly younger than non-regular active gamers [6], in the present studies we did not find support for this notion. Yet, there are indications that younger children are more interested in active gaming than adolescents in general [5;16]. In accordance with this focus group findings also suggest that active games are more suitable for younger children than for adolescents [17;18]. Dutch 8-12 year olds mainly reported to prefer active games to non-active games [17], while Dutch 12-16 year olds mainly preferred non-active games to active games (chapter 4). Moreover, active games were perceived as more appropriate for younger children than teenagers according to 10-14 year old New Zealand children [18].

Though more research is necessary, based on our studies active games seem especially suitable for reaching adolescents attending a lower level of education, and at least equally suitable for girls and boys. Other studies suggest active games might be more appropriate for younger children than for adolescents.

Mixed evidence on associations between active gaming and other energy-balance-related behaviors

Sedentary behavior and physical activity

Active gaming may only be beneficial for energy balance when it replaces sedentary activities such as non-active gaming or TV viewing. We found that adolescents interested in active gaming were generally also more interested in non-active gaming. This was similar to the finding of O'loughlin and colleagues who found that active gamers were more likely to play non-active games than adolescents who did not play active games [7]. This suggests that an interest in active and non-active gaming is associated, which is desirable when aiming to replace non-active game time by active game time. However, actual time spent in active gaming and non-active gaming was not correlated (chapter 3). This suggests that when adolescents spend more time on active gaming it may not result in less non-active game time. Moreover, we found a small- but significant- association between active game time and TV/DVD time, which concurs with the finding of O'Loughlin that active gamers were more likely to watch more than 2 hours of television per day than adolescents who did not play active games [7]. Thus promoting active gaming could also result in more sedentary time. On the other hand, it may particularly attract adolescents who are already heavily engaged in screen activities. Causal inferences of these results should of course be made with caution, since these were cross-sectional associations. Three experimental and longitudinal trials have been conducted on this topic and show mixed evidence [Chapter 7); 19;20]. In our trial (chapter 7) we found that providing active games including an encouragement to

replace non-active games with active games, decreased self-reported non-active game time and total sedentary screen time compared to a control group. However, in an earlier study no change was found in self-reported non-active game time after providing active games [19]. Important to highlight is that in both these trials non-active game time was self-reported and the intervention groups were explicitly encouraged to play the active games, potentially influencing their self-report. The only trial that measured behavior objectively was a cross-over trial showing that replacing non-active games with active games decreased total sedentary time in the after-school period but not across the whole week [20].

Another important energy-balance-related behavior is physical activity. Concerns have been expressed that adolescents may play active video games instead of other more traditional physical activities such as playing outdoors or sports. Playing outdoors and practicing outdoor sports activities offers the benefits of being outside such as fresh air, exposure to sunlight (vitamin D), connection with nature and social interactions and in general it requires higher energy expenditure than active gaming [21;22]. Three cross-sectional studies that aimed to shine more light on this possible compensation issue show mixed results [6;7;23]. Two out of three studies found no difference in physical activity between adolescents who did and who did not play active games (or less than 1 hour per week) [6;7]. Yet, a more recent study in young adults found that female active gamers reported more (47 minutes) physical activity in the past week than females who did not play active games [23]. It is not clear if these extra 47 minutes reflected active gaming itself or other physical activities. The study also showed that female active gamers were more likely to believe active games were a good way to integrate physical activity into their lives than male active gamers (89% vs. 62%). Therefore, it might be that females were more likely to include active gaming when answering physical activity questions than males. There is initial evidence to support this idea, as another study suggested that adolescent girls who play active games partially internalized active gaming as a physical activity behavior while boys may not view active gaming as physical activity [24]. Besides these cross-sectional studies, three longitudinal experimental trials have been conducted. Two of them did not found effects of providing and promoting active games on self-reported (Chapter 7) and objectively measured [19] physical activity. One cross-over trial though did find that replacing non-active games with active games increased objectively measured physical activity, but only in the after-school period and not across the whole week [20].

In sum, it is not clear yet how active gaming influences other physical activities and sedentary activities and thus the energy-balance. More longitudinal and experimental research including objective measures of physical activity and sedentary time is needed to shed more light on such compensatory behaviors.

Energy intake

Eating and drinking are also important energy-balance-related behaviors. In the 24-hours recall study we found that active game time was weakly associated with higher snack intake (chapter 3), while our trial provided no evidence that providing active games influenced consumption of sugar-sweetened beverages or snacks (chapter 7). Also an earlier study by Maddison et al., [19] in which participation in active games was higher than in our trial, found no effects of an active game intervention on snack intake either [19]. In all these studies dietary intake was self-reported and thus potentially influenced by social desirability or recall bias. De Groot et al., [25] evaluated objectively measured consumption of potato chips and coke during different screen activities in young adult Dutch males and showed that energy intake during active gaming was not different than during non-active gaming and watching TV. These results are in line with two other laboratory studies that evaluated energy intake during active and non-active gaming in young adults [26] and in children [27]. While in the studies of De Groot et al. [25] and Mellecker et al. [27] only energy intake was measured, Lyons et al., [26] additionally measured energy expenditure. Despite the equal energy intake during different activities, differences in energy expenditure in favor of active gaming were found [26]. Although the resulting lower energy surplus may make active gaming a healthier alternative to non-active gaming and watching TV, also active gaming resulted in a positive energy balance where caloric intake from foods and beverages exceeds the amount of calories expended during the activity [26]. Important to note it that all these studies [25-27] assessed energy intake during the activity only, but not afterwards. Adolescents consume more during an ad libitum lunch (10 minutes later) irrespective of hunger and appetite after playing non-active games for one hour than after resting in a relaxing sitting position [28]. It would be valuable to examine this potential compensation effect afterwards for active gaming and to evaluate whether these possible compensation effects differ between active gaming and non-active gaming.

In summary, it can be concluded that there is no clear evidence that active gaming leads to higher energy intakes during game time. However, it may be that after the gaming activity, energy intake may be higher. A longitudinal experimental study using valid measures of energy intake would be useful to get more insight in these potential unanticipated effects of promoting active gaming.

Adolescents seem to appreciate non-active games over active games

Our focus groups revealed that adolescents generally like active games, but preferred non-active games. Adolescents thought that active games were more boring, graphics and story line were less sophisticated, had more malfunction in technology and controllers, and had less variety in games compared to non-active games (chapter 4). For an active game intervention it seems therefore important to provide a wide range of active games and refresh the games often to keep adolescents interested. Aspects that adolescents did like about active games were merely related to physical activity and the

interactive aspect in the active game. Further, active games were considered more social than non-active games, as confirmed by previous studies that found that group play can encourage participation in active games [29;30]. Hence, the social nature of active games seems an aspect that could be used to motivate adolescents towards active games. Our findings that adolescents had a positive attitude towards both active and non-active gaming (chapter 5) and the suggested common interest of adolescents in both active and non-active gaming (chapter 3) seemed promising. However, adolescents preferred non-active games over active games (chapter 4), which indicates it may be challenging to motivate non-active gaming adolescents to replace non-active gaming with active gaming. Our finding that a more positive attitude towards non-active games was associated with a lower likelihood to play active games (chapter 5) substantiates this.

In summary, active gaming may be a way to encourage physical activity as adolescents do appreciate active games, but competition with non-active gaming seems tough.

Correlates of active gaming and non-active gaming are partly different

We found various personal, social and game-related correlates of active gaming and these were partly different from correlates of non-active gaming. More than non-active gaming, active gaming seems to be influenced by gaming behavior of brothers and sisters. Consistent with previous studies [Chapter 4; 29;30], our findings indicated that active gaming is more likely if siblings, and to a lesser extent friends, also play them regularly. Hence, to promote active gaming it seems wise to focus on multi-player games instead of individual play. Consequently, for our trial we decided to promote multiplayer play and to provide an extra game controller as part of the active game intervention. Further, we found no association between attitude towards physical activity and active game play, thus no support for the concern that only youth who like physical activity and are already physically active (and therefore not the main target group for physical activity promotion interventions) play active games. Habit strength was a correlate of both active and non-active gaming, indicating that both types of gaming may be habitual behaviors. It is important to know the extent to which gaming is a habitual behavior (more unconscious) or a planned behavior (more conscious), as changing both types of behavior request different intervention strategies. Habits are learned responses to cues in the environment that have become automatized. Such automatic behaviors, like habits, are often difficult to change [31] and require breaking existing mental associations between cues and gaming, while building new ones. For example placing the active game console in a highly visible and accessible place could serve as a cue for playing. This was also mentioned in the focus groups (chapter 4). In addition, we found that active game play was associated with lower engagement experience during game play. However, we do not know if it refers to a trait in the sense that some adolescents become more easily immersed when gaming or a state in the sense that some games have stronger immersive qualities (or a mix). Again, these findings should be interpreted with caution, since these were all cross-sectional associations, and thus no conclusions can be drawn about

causality. All in all, the correlates of active and non-active gaming provided input for further research into correlates and provided input for the development of the active game intervention.

An active game promotion intervention did not contribute to the prevention of unnecessary weight gain in adolescents

We found no evidence that providing active games and promoting its use, did contribute to preventing unnecessary weight gain among gaming adolescents. Only adolescents who played non-active games for at least two hours per week were included in our trial and there was no inclusion criterion based on weight status. As a result we mainly included adolescents with a healthy body weight, which may have minimized the ability to see significant differences in changes in anthropometric measurements. Indeed, the intervention group remained relatively stable regarding most anthropometrics over ten months and the majority remained having a healthy weight for the duration of the intervention. In the control group anthropometrics decreased somewhat, resulting in a significant difference between the control group and intervention group in favor of the control group. A possible explanation may be an increase in the consumption of snacks and sugar-sweetened beverages or a decrease in other physical activities in the intervention group. However, we consider this explanation unlikely, as the intervention did not significantly affect these behaviors.

The intervention did not succeed in enabling and motivating the adolescents to play the active games for a substantial amount of time; only 14% of the participants in the intervention group managed to play at least one hour per week throughout the 10-month intervention period. The process evaluation confirmed the findings of the survey and focus groups that adolescents think active games are boring and prefer non-active games. Currently available active games may not be appealing enough to adolescents and cannot yet compete with non-active games. In contrast, other studies did find beneficial effects of active gaming on anthropometrics [19;32;33]. However, these studies focused on treatment of overweight and obesity instead of prevention of unnecessary weight gain as in our study. Further, they gave a stricter instruction to use the active games [19;34] or embedded the active games in a structured or multicomponent program [32;33]. Nevertheless, we found less self-reported non-active game time (-1.8 hour/week) and a 0.8 times lower geometric mean of sedentary screen time in the intervention group compared to the control group, suggesting that the intervention did succeed in targeting underlying behaviors of overweight. However, these behaviors were self-reported.

In summary, we did not succeed in stimulating non-active gaming adolescents to play active games a substantial amount of time instead of non-active games in a 'free-play setting'. We found no indication that providing active games in a home setting contributes to prevention of unnecessary weight gain. Other studies suggest that active

games might be more successful as part of a treatment program for overweight and obesity, embedded in a broader program or with more prescription for usage instead of a stand-alone prevention tool and relying on spontaneous use.

Methodological reflections

The specific methodological issues regarding the separate studies are discussed in the previous chapters describing these studies. This section will discuss some general methodological considerations of the overall project.

Conducting research in adolescents

This thesis focuses on adolescents aged 12 – 17 years old and the findings of this thesis cannot be generalized to other age groups. The rationale to focus on adolescents, as explained in more detail in the introduction, was the high prevalence of unhealthy overweight-related behaviors [8], and the fact that weight status and life style behaviors during this life stage often track into adulthood [35]. However, conducting research in adolescents involves some specific challenges in terms of recruitment and retention, consent and confidentiality and the additional role of parents [36]. Even though it seems easy to reach adolescents through schools, recruitment is often difficult because of strict rules regarding consent and because many adolescents have other interests than participating in research [36]. Studies involving more interactive and digital tools (such as internet, texting, and games) seem to be more appealing to adolescents [36].

Besides recruitment, also data collection can be challenging in adolescents; during our data collection we experienced once that an adolescent was not filling in the questionnaire seriously but was making up answers on purpose, so we excluded the questionnaire for the analysis. However, often researchers are not present when the adolescents complete questionnaires, making it hard to judge whether answers are valid or not. Adolescents might click through or skip questions to be finished quickly and only participate for the incentive. Therefore, we made the questionnaires as user-friendly as possible by using a structured online tool, or arranged that adolescents could complete the questionnaire during school time so not at the expense of their leisure time. Also in qualitative data collection one should be aware of adolescence-specific challenges. We conducted focus groups with adolescents to evaluate their views on active and non-active games. Possibly the adolescents were influenced by the presence of the researcher and other adolescents, as adolescent life stage is characterized by increasing peer influence [37]. Parents and teachers were not allowed to be present during the focus groups, to prevent that adolescents would not feel comfortable to speak freely. Further, we tried to create an open and relaxed atmosphere in which all participating adolescents felt comfortable and we gave everybody the opportunity to speak. Despite these efforts, it still could be that some adolescents said things under the influence of peer-pressure or were afraid to contradict their peers.

Objective measures could overcome these problems, but are not always available or face too many practical issues. We used objective measures for proxy measures of adiposity (BMI, skinfolds, hip and waist circumference). However, a potential problem with these anthropometric measures in adolescents is that they change considerably over time with large individual differences because of differences in onset of puberty. Puberty concurs with hormonal changes, which can cause a rapid increase in height and changes in amount and location of body fat [36-38]. Consequently, pubertal stage could be a confounder and preferably should be adjusted for in the analyses. We decided not to do this because the assessment of pubertal status is sensitive and intrusive for adolescents [36]. Further, because we randomized participants in our trial we assumed that puberty status is evenly distributed in both the control group and intervention group and probably did not influence the results.

Recruitment

We used schools as a main source for recruiting adolescents, as this is the most convenient place to recruit adolescents. We succeeded to include a representative group of adolescents in the survey in terms of age, sex, ethnicity and educational level [Chapter 2; 39], which is important in order to get a valid estimation of prevalence of active and non-active gaming of adolescents in The Netherlands. The 24 hours-recall diary investigated among active gamers how active gaming is associated with other behaviors. Hereto, we needed adolescents who played active games and so we collaborated with a panel agency that had access to a large group of adolescents who met that criterion. Hence, the study population was not representative for a general group of adolescents, as not all adolescents play active games. Finally, in the trial we used a wide variety of sources and it took a lot of effort to recruit the 270 participants; thousands of letters and flyers were spread at schools, advertisements were placed on game websites and newsletters et cetera. This probably means that a highly selective group of gaming participants was recruited in our trial, which may not be representative for gamers in general. We focused on PlayStation 3 gamers, because we found that many adolescents play games on this console. However, the findings may not be fully generalizable to other console gamers. Further, our participants consisted of a group of adolescents who spent a relatively high amount of time in playing non-active games, and comparing them to a general group of Dutch adolescents they could be called 'excessive' gamers. The intervention may be more effective among less 'excessive' non-active gamers since ´recreational´ gamers might be easier to motivate to active gaming. It is worth noting though that the internal validity could be considered high, because of the extremely low drop out.

Study designs

Strong aspects of the studies in this thesis are the systematic approach and wide variety of study designs and research methods. We used focus groups to get more in-depth knowledge on the views of adolescents, which were further investigated quantitatively in a survey. To shed more light on how active gaming is associated with

other energy-balance-related behaviors, we conducted a diary study including multiple 24-hour recalls. In this study adolescents filled in their activities for 7 days randomly spread over one month. Because we assessed 7 random unannounced days instead of a single point in time, we maximized the chance to capture a true representation of normal daily behavior. Finally, to evaluate the effects of an active game intervention we used the 'gold standard' in scientific evidence, i.e. a randomized controlled trial.

Some limitations should be mentioned in the study designs we used. Although focus groups are very suitable for gaining in-depth knowledge about a relatively new subject, a limitation is that the findings are not generalizable. Therefore, we additionally investigated the findings quantitatively in a survey. In turn, a limitation of the survey was the cross-sectional design, which precluded conclusions about causality. However, we did not aim to examine causality, but to explore associations to inform the active game intervention development. This causality inference problem also applies for the 24-hours-recall study. Lastly, also some limitations apply to the randomized controlled trial. The participants, researchers and research assistants were not blinded, as this was complicated because of the nature of the intervention and for logistic reasons. Consequently, the control group knew that they were the control group and that the intervention consisted of receiving an active game application including active games. This could have resulted in contamination. However, the process evaluation and self-reported game behavior findings do not confirm this concern. An alternative design that can be considered in future active game studies is a randomized controlled trial nested within a cohort study (RCT nested in a cohort design). This design can overcome problems regarding recruitment and not being able to blind participants that are associated with regular randomized controlled designs [40]. Further, to prevent fading out interest in the active games, future studies might consider adjusting the intervention (e.g. changing the active games and/or implementation strategies) during the study period, i.e. an adaptive trial.

Data collection and measures

We used mixed methods to collect data: focus groups to collect qualitative data and questionnaires, a 24-hours-recall diary and anthropometric measures to gather quantitative data (self-reported and objective). Below we elaborate on some issues related to self-reported measures and measuring anthropometrics.

Measuring self-reported behavior

We mainly used self-reported (behavioral) measures as there are no appropriate objective measures available yet for the aspects we were interested in. A general limitation of self-reported measures is the liability to recall bias and social desirable answers.

Time spent playing active and non-active games was assessed using questions derived from existing and validated questionnaires, however we modified the questions to reflect

the target behavior gaming and the modified version was not validated. So we do not know to which extent the assessed gaming behavior reflects actual gaming behavior. The correlates of active and non-active gaming were also based on self-reported data and consequently the same limitations apply as mentioned above. We mainly used readily existing and valid instruments to measure potential correlates. However, to ensure an acceptable length of the questionnaire we had to shorten some of the scales, which might have influenced the validity of the included measures. To minimize possible negative influences on validity we removed the items with the lowest factor loading. In the 24-hours-recall diary study, we assessed adolescents' time spent in a wide range of activities conducted in the past 24 hours. We wanted to get a complete picture; hence we included many activities in the diary resulting in a very long questionnaire. The length of the questionnaire and the fact that it had to be completed seven times, could have resulted in less reliable answers. We used a structured online diary with programmed routings to make it as easy as possible to complete it, but this also made it easy to click through the questions very fast without reading or thinking about the answer. Again, this questionnaire was based on validated questionnaires, but modified (to target gaming behavior and make it suitable for the online tool) and the modified version was not validated. Further, we used text messages to improve response rates. In the trial, physical activity and sedentary behavior were again self-reported and these self-reports have limited validity [41;42]. To assess active game behavior the adolescents filled in a game calendar every day they played active games. To improve compliance we made the calendar attractive and easy to fill in. However, the validity of the game calendar is unknown.

An alternative to self-report measures for assessing physical activity and sedentary time is accelerometry. Accelerometers are a valid method to objectively measure physical activity and sedentary time and have been previously used in active game trials [19;20]. However, compliance to the accelerometers protocol is often poor and there are many potential practical problems (e.g. loss or damage) when using them in large-scale studies [43;44]. Moreover, it can be questioned whether accelerometers are sensitive enough to accurately detect physical activity elicited by active gaming. Many active games require mainly upper body movements that are difficult to detect by an accelerometer worn on the hip [45]. A solution might be to wear the accelerometers on the wrist [46]. Further, accelerometers do not provide information on the type of activity, and where and with whom activities are being performed. Nevertheless, objective measures are recommended in future active game studies, but preferably in combination with self-report. Furthermore, other objective measures should be explored, for instance data (on game time and activities) that are stored continuously in game consoles. Baranowski and colleagues tried to use the game play data recorded by the Wii console [47]. However, these data appeared not very reliable, as some time periods of playtime recorded by the console were excessive (e.g. 24 hours) suggesting that players left the console on without actual playing. Further, the console does not record who is playing the game: the child, a friend, sibling, parent, or others [47]. Other consoles also store game data but our experience learns that companies

are not always willing to provide them because of privacy issues. Despite these limitations and problems, console-recorded data seem of potentially high value for research purposes and it is recommended to further explore how this data can be retrieved and analyzed.

Measuring anthropometrics

A strong feature of the trial was that we objectively measured height, body weight, waist and hip circumference, and skinfold thickness. Height and weight were used to calculate BMI, which is considered a suitable and accepted proxy measure of adiposity [38]. However, as discussed earlier there are also some limitations and considerations regarding using BMI in adolescents. Whereas in adults the BMI cut points that define obesity and overweight are not linked to age and not dependent on sex, they are in growing adolescents. Hence, for BMI to be meaningful in adolescents it must be compared to a reference standard that takes into account age and sex [48]. Therefore we decided to use BMI-SDS as the primary outcome variable. As recommended we used an external reference (the population from 1997 described in Schönbeck et al., [9] instead of an internal one (sample-based) to calculate BMI-SDS [48]. However, there are discussions and disagreements about what the optimal BMI-related measure for evaluating change is [38]. For example, it is has been suggested that crude BMI should be used as the analytic variable with adjustment for age and sex in the actual analyses [38]. Yet, by using such an internal reference standard (sample-based) for age and sex, the interpretability of the findings decreases [48]. Alternative to BMI are direct measures of body fat such as dual-energy radiograph absorptiometry [43]. However, these direct measures are expensive and time consuming, and were therefore not suitable for inclusion in the trial that we conducted.

Games for overweight prevention in a broader perspective

Video games are an integral and important part of adolescent's life [1;2;49;50]. It has even been suggested that a life without is impossible for adolescents [20;49]. Therefore, it makes sense to find ways to use game technology to achieve positive effects, such as promoting healthy behaviors, rather than try to ban it and only focus on potential negative effects such as sedentariness, aggressive behavior, increased level of hyperactivity, lower levels of prosocial behavior and life satisfaction [51] or neglect of school responsibilities [50]. As such, more and more initiatives arise that try to harness the broad appeal of video games for health promotion.

Games being used for another purpose than pure entertainment (e.g. to educate, train, or promote behavior change) are called 'serious games' [52]. Serious games are increasingly prevalent in a broad area of domains such as defense (military training), education, and health care [52;53]. Active games, where this thesis focused on, can also

be considered a form of serious games. Although the active games that we focused on were originally developed for entertainment reasons, they can also be used for other (serious) purposes such as physical activity promotion. The use of game strategies and techniques is not limited to consoles only, as we see a growing use of game elements in mobile phone apps [54]. This usage of game strategies and features in non-gaming contexts is called 'gamification' (55). Examples of game strategies (i.e. the motivational elements typical for game-design) are Challenge, Phantasy, Story line, Competition, and Exploration [56;57]. The use of game strategies in interventions is promising as it might make interventions more fun and appealing. Hence, incorporating the game strategies and game techniques that make entertainment games appealing and addictive (in a positive way) in behavior change programs, might contribute to overcome major setbacks associated with traditional programs such as low reach of the at risk groups (e.g. people with a low social economic status), motivational issues, low adherence [58].

Below it is discussed how game strategies and techniques can be used in digital devices for promoting healthy energy balance -related behaviors (e.g. diet, physical activity and sedentary behavior) in order to prevent overweight. Serious games played on consoles or personal computer, and serious games (apps) played on mobile phones are considered.

Serious games for overweight prevention played on consoles

Besides active games, also other forms of serious games for promoting healthy energy-balance-related behaviors are being developed. Escape from Diab and Nanoswarm are examples of serious games (played on a Mac computer) aiming to promote healthy energy-balance-related behaviors that incorporate both behavior change techniques (e.g. goal setting, modelling) and game elements (e.g. story line, exploration) [59]. These are action-adventure games comparable to the experience of commercial quality video games and incorporate behavior change techniques woven in and around the game story. The game Escape from Diab is about an athletic adolescent, DeeJay, who falls through a door while playing soccer with his friends. He awakens in a colorless land called Diab, which is ruled by King Etes who oppresses the people living in Diab by 'forcing' them to have unhealthy diets and to be physically inactive (story line). Deejay tries to escape from Diab and King Etes with his friends by introducing them to healthy eating and sufficient physical activity as a way to gain the mental acuity and physical fitness needed to escape from Diab (exploration, modeling). During game play the player has to set goals regarding diet and physical activity (goal setting) [60]. A randomized controlled trial showed that playing Escape from Diab and Nanowswarm resulted in increased fruit and vegetable intake in children [59], making it a promising tool to contribute to the prevention of overweight. A limitation however of these and many other current available serious games, is that they do not require physical activity and are often played inside while seated behind a computer or TV screen. Promising developments are serious games that also require physical activity to play the game, such as 'Alien Health'

[61]. In this serious game the player learns about healthy diet while engaging in short cardio exercises using Kinect (an active game) technology.

Emerging evidence suggests that serious games can be effective in changing health behavior or its determinants, although effectiveness varies between the serious games [58]. A meta-analysis showed that serious games benefit from a strong focus on gaming theories or foundation in both behavioral and gaming theories [58]. However, it is unclear which specific behavior change strategies, game strategies and game mechanics determine the effectiveness of a serious game for healthy lifestyle promotion. There is a lack of systematic descriptions of the game design and evaluations of developed serious games and there seems a need for a conceptual framework combining behavior change theories with game design theories to guide and evaluate serious games for healthy lifestyle promotion.

Serious games for overweight prevention played on mobile phones

Another promising digital device for promoting healthy behavior using game strategies and techniques are mobile phones. The enormous rise in mobile phone and smartphones use and technique has resulted in an exploded availability of apps and mobile games, including apps for healthy lifestyle such as promoting physical activity, and a healthy diet [62-65]. Apps offer the opportunity to provide tailored feedback and advice at the appropriate time and place and real-time and place assessment and feedback that are more likely to be effective for behavior change [62]. Moreover, these mobile games and apps can take players outside and overcome the downsides of sitting inside behind a computer [65]. Mobile phones are a very suitable device for gamification and health promotion, because of technologies such as GPS (Global Positioning System), built in accelerometers and external wearable sensors (e.g. measuring heart rate, blood pressure, blood sugar). To illustrate, GPS provides information on location, distance, time and speed, which can be used as part of game play that requires players to go outside and perform game tasks in specific areas in their neighborhood [65]. In this way game maps are existing streets in the real world and players are for example instructed to collect items or treasures or to avoid items/traps that are put somewhere on the game map (and thus also in the real world). In this way the 'real world' is combined with the 'virtual world' (also called augmented reality), and the 'real world' is being used as a 'game world'. A growing amount of mobile games and apps that incorporate GPS become available [65]. Examples of game types are geocaching (games virtual treasure hunting and visiting new locations), geodashing (competitive online game in which the entire world is the playing field and players receive a list of random locations (dashpoints) and they have to visit as many of these points as possible within a specific amount of time), geohashing (an adventurous journey to random places within a given area). A well-known and popular example of a physical activity promoting app using gamification and GPS is Zombies run, which has more than 800.000 players (https://www.zombiesrungame.com/ [66]). This is a running app in which the player hears an adventurous story through his/her

headphones and receives assignment (e.g. collect things, warnings that the zombies are coming and he/she need to speed up) and when the player get back home he/she can use the collected items or achieved assignments to build their own base.

Incorporation of game features is prevalent in apps, but often limited to only a few game strategies and techniques [64]. Also the use of evidence based behavior change techniques is scarce, while this is important for apps to be effective tools for changing health behavior on the long term [62;63]. Unfortunately, little is known yet about the effects and sustained use of mobile apps (using game elements) for prevention of overweight. A review has suggested that mobile health interventions may be effective in adult weight management in the short term [67]. Also, pilot studies have reported that mobile apps can be a feasible tool for weight management [68;69]. However, most of these apps do not incorporate game strategies (or only a few). Collaboration between game designers, health professionals and behavior change experts is warranted to link game strategies and techniques to evidence based behavior change techniques and incorporate those in apps. Future research should identify which of these game strategies and behavior change techniques are most effective in changing behavior.

Active video games in a broader perspective

This thesis evaluated the potential of using active video games for overweight prevention in gaming adolescents in a home setting. We focused on the commercially off-the-shelf active games such as the Wii, Dance Dance Revolution, PlayStation Move, or Xbox Kinect. These games are developed for commercial reasons, to make profit, and not with the aim to promote physical activity although these games might be used to that end. Not all these active games elicit moderate intense physical activity, which is required to contribute to meeting the physical activity guideline (i.e. accumulate at least 60 minutes of moderate to vigorous physical activity per day). Next to these commercial off-the-shelf active games, there are also active games that are specifically developed to increase physical activity or decrease sedentary time [70;71]. These active games might be more suitable for physical activity promotion as some of these games seem to require more intense physical activity then for example the Wii [72]. Most off-the-shelf active games are mainly developed for in home use, although they also can be used in other settings, such as school, playgrounds, workplace or nursing home. Combining this setting might increase impact. Further, other target groups than adolescents can be considered. Below, these other settings and target groups are being discussed.

Active video games in a school setting

This thesis focused on active video games in the home setting, but several studies indicated schools might also provide valuable opportunities for active gaming [32;73-75]. Schools can be considered as an ideal setting to improve health behaviors in adolescents,

because of the wide reach in terms of socio-economic status and ethnic backgrounds [76]. Further, adolescents spend most of their time in school sitting so there is much to be gained with respect to reducing sedentariness. An example of combining active game technology with school lessons to decrease sedentariness is the 'Mobile Class' [71]. Further, active games might be used in physical education to enhance interest and competence [77-79]. So far most studies on active games in a school setting have small sample sizes [32] or are observational [73;75], so little is known about effectiveness. Further, studies showed that sustained use of active games is challenging in a school setting. We need more insight in how active games should be implemented in a school setting to achieve sufficient and sustainable use of active games. Further, we need randomized controlled (or nested cohort) trials to get more insight true effects on health behaviors and indicators of overweight.

Active video games in the outdoors

Game elements can also be used in outdoor play facilities. In this way the benefits of gaming (e.g. high appeal, motivation and fun) are combined with the benefits of being outside. Hence, it meets the preference of parents that their child plays outside [17]. Examples are the Swinxs and YalpSona that have been shown to elicit an energy expenditure between 7 and 10 METs and thus sufficient to contribute to meet the physical activity guideline [70;80]. As far as I know, no research has been done yet on the effects on physical activity behavior change on the long term.

Active video games in a work setting

There are also games that focus on improving employee's health and wellbeing [81;82]. Active games can for example be implemented at work to stimulate physical activity in employees and to interrupt sedentariness. Sedentary behavior is known to be associated with negative health outcomes in adults and for many people work is a main source of sedentary time [83]. Active games such as Lasersquash might be placed on the work floor to motivate people to interrupt their sedentary time and be active for a couple of minutes [82]. Playing Lasersquash can elicit moderate to intense physical activity in employees, however again sustainable sufficient participation is challenging [84].

Active video games for therapeutic use

Active video games seem also to be a promising tool for therapeutic purposes in rehabilitation and illness management: e.g. balance training in elderly, burn wounds therapy, rehabilitation among children with cerebral palsy, to combat cancer-related fatigue in hospital patients, physical activity promotion in hospitalized inpatients or long-term care residents, Parkinson disease therapy, recovering from stroke [85]. The benefit lies in that games may make exercise and therapy less boring and more fun or can provide distraction from pain or fatigues. A recent review showed that the majority of studies showed promising results, but that most studies were pilot trials and there were few randomized controlled trials [85].

Implications for future research and practice

Implications for future research

Most studies so far focused on energy expenditure showing that playing active games leads to light to moderate intense physical activity. Studying the effectiveness of active games for overweight prevention is relatively new and shows conflicting results; some studies found significant effects on physical activity, sedentary behavior and BMI while others did not. Therefore, more randomized controlled (or nested cohort) trials with longer follow-up are of high value to bring the field of active games further. However, the level of participation and continuation in active game play is often low. Therefore, the first step is to examine which factors can enhance participation in active game play. Simply providing an active game seems not enough to result in sufficient active game play and increase physical activity. Therefore it is important to learn more about the optimal circumstances, conditions and implementation strategies. Should the active games be embedded in a structured program for example at schools? Does integrating a competition or cooperation element contribute to increased active game time [86]? How can we achieve that active games hook people in the same way that non-active games do? Do we need new (better) active games? Are active games more promising in other target groups?

Up till now most studies focused on commercially available active games that were not primarily developed to promote physical activity. Consequently, these active games include little or no theory based behavioral change techniques [87]. As theory based interventions are more likely to be effective (88), it is recommended that researchers, game designers and adolescents collaborate in designing and evaluating theory based active games that are attractive to the target group. Future research is necessary to show whether these active games that are specifically designed for physical activity promotion and based on evidence based behavior change theories, are indeed more effective than the commercial active games. Therefore it is important to gain insight in which behavioral change techniques and game strategies are associated with effectiveness. The world of games and technology is developing rapidly and new technologies and applications arise fast. For health researchers to keep up with this rapid developing world and learn about the benefits and possibilities for health promotion, more cooperation with computer scientists, game designers and game industry is desirable. Further, as mentioned above, active games are only one form of how games can be used for health promotion. Future studies should also focus on other forms of serious games and other digital devices that use game features such as mobile games and their potential contribution to overweight prevention.

Implications for practice

Recommendations for game developers

Our study results indicate that there is need for a new generation of active games to be able to compete with non-active games. Straker et al. [89] indicated that for active

games to be sustained as popular non-active games, they may need to incorporate features that are more aligned to relevant principles that are used in non-active games. They also recommend multidisciplinary collaboration to further develop and apply a comprehensive set of principles for best practice of active games [89]. In addition, studies have shown that not all active games are truly active. Most Wii games for example only require low intensity physical activity and it easy to compete with very little body movements (for example the tennis games can easily be played while sitting on the couch and only making small wrist movements). The PlayStation EyeToy games generally require only small arm movements similar as in the Wii games. Active games that require both upper and lower body movements, e.g. Dance Dance Revolution, generally require the highest energy expenditure [90]. Smart phones and new technologies such as GPS (as described above), wearable sensors, but also virtual reality glasses (e.g. Occulus) provide many opportunities to bring active games a step further.

Recommendations for parents and health professionals

We found no evidence that providing active games to adolescents is effective in contributing to the prevention of overweight in adolescents. So based on our study results we cannot recommend parents to buy active games instead of non-active games.

Main conclusions

Playing video games is an enormous popular activity and is still increasing in popularity. Inspired by the new development of active games, this thesis evaluated the potential of active video games as a novel overweight prevention tool for gaming adolescents. Based on this thesis, the following conclusions can be made:

- The majority of adolescents play video games and almost half play active video games, but time spend on playing active video games is much lower than on non-active video games.
- Both boys and girls play active video games, and especially adolescents attending lower educational school levels play active video games.
- Playing active video games is considered a social activity, as it is played often with friends and brothers and sisters. Further, having other people (brothers/sisters and friends) around you increases the likelihood of playing active games yourself.
- Gaming adolescents do not consider active video games as an attractive alternative for non-active video games. Together with the finding that habit strength is an important correlate of actual gaming behaviour, it may be hard to replace non-active game time with active game time.
- Playing active video games does not seem to replace other physical activities. We found preliminary indications that playing active video games can result in less sedentary time and non-active game time. The effects of playing active vieo games on energy intake are unclear yet.

- Providing and promoting active video games to adolescents who already play non-active video games does not result in a substantial active game play time and does not contribute to the prevention of overweight.

Future studies are necessary to evaluate which strategies can motivate non-active gaming adolescents to play active games for a substantial and sustainable amount of time instead of non-active video games or whether active video games might be more suitable for other target groups. All in all, for now, we do not recommend to provide active video games to gaming adolescents in their home with only a light encouragement to play them.

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Summary

General introduction

Overweight in youth has substantially increased over the past decades and is a major public health concern. Youth overweight is associated with negative physical and psychological consequences during childhood itself and in addition contributes to higher health risks later in life. The underlying mechanisms of becoming overweight are complex and involve besides genetic and hormonal factors, also cognitive, motivational, behavioral and environmental factors. But simply stated, overweight is the consequence of excessive weight gain (i.e., weight gain that exceeds weight gain caused by regular growth), caused by a long-term positive energy balance, i.e., when energy intake is larger than energy expenditure.

An important way to contribute to the prevention of excessive weight gain is to encourage behaviors that increase energy expenditure and reduce energy intake, i.e. restoring the energy balance. Important energy balance-related behaviors (EBRBs) are physical activity, sedentary behavior (such as watching television, playing non-active video games) and energy intake (such as consumption of snacks and sugar-sweetened beverages). Although there are many programs aimed at treatment of overweight and obesity, results have often been disappointing, especially regarding long-term effectiveness. Therefore, an important strategy is to prevent excessive weight gain and in this way thus prevent the development of overweight and obesity.

Adolescents are an important target group for overweight prevention, as adolescence is a critical life stage in the development and persistence of overweight into adulthood. The adolescent life stage is characterized by unhealthy patterns in energy balance-related behaviors: high intake of sugar-sweetened beverages and snacks a decrease in sport participation and other physical activities and high levels of sedentary behavior. Furthermore, during adolescence the amount and location of body fat changes a lot. However, adolescents are also a difficult group to motivate for health behavior change: adolescents often do not perceive long term consequences of their behavior, have little interest in health, are experiencing stress because of low self-esteem, and have a powerful drive for independence and peer association. These extra challenges in adolescent health promotion may have led to the fact that there are relatively few high quality intervention studies on overweight and obesity management in adolescents compared to other age groups.

Because of these challenges specific to adolescence, it is recommended to use novel approaches tailored to adolescents' needs and preferences in order to promote their health. Behavior change interventions are generally believed to be more effective if they fit the interest of the target group. An activity that fits the interest of many adolescents is playing video games. Video games are an integral and important part of adolescent's life and it has even been suggested that a life without games is impossible for adolescents. The broad appeal of video games and the rise of a new generation of video games, namely active video games (video games that require physical activity to play) inspired us to evaluate the potential of active video games as a novel overweight prevention tool for gaming adolescents.

Therefore, the aim of this research project was to evaluate whether providing active video games in the home setting, can contribute to prevention of excessive weight gain in gaming adolescents by reducing sedentary behavior and increasing physical activity.

Main findings

Part 1: Analysis of gaming behavior

In **chapter 2** the results are presented of a cross-sectional survey in secondary schools among adolescents 1) to evaluate how many adolescents play active games and how much time they report to spend playing them, and 2) to identify subgroups in active and non-active gaming behavior. Of the participants, 3% reported to play exclusively active games, 40% reported to play both types, 40% exclusively non-active games, and 17% reported to not play video games at all. The active gaming adolescents played the active games on average on 1.5 days per school week for 36 min and 1 day per weekend for 42 min. The non-active gaming adolescents played on average on 3.3 days per school week for 65 min and 1.4 days per weekend for 80 min. Adolescents attending lower levels of education were more likely to play active games ≥1 h per week than adolescents attending higher educational levels. Boys and older adolescents were more likely to play non-active games >7h per week, than girls or younger adolescents. In sum, this study suggested that many adolescents play active games, especially those following a lower educational level, but time spent in this activity is relatively low compared to time spent playing non-active games. To be feasible as a public health strategy, active gaming interventions should achieve more time is spent on active gaming at the expense of non-active gaming.

Chapter 3 describes a 24-hour recall diary study among adolescent active gamers in order to get more insight into how playing active games influences energy balance. Since active video gaming can only be beneficial for weight management when it replaces sedentary activities and not other physical activity, and when it is not associated with a

higher energy intake. Adolescents (12–16 years) with access to an active video game and who reported to spend at least one hour per week in active video gaming were invited to participate in the study. Adolescents reported the time spent in playing active and non-active video games and on other EBRBs through electronic 24-hour recall diaries on five randomly assigned weekdays and two randomly assigned weekend-days in a one-month period. Findings indicated that adolescents who reported to play active video games on assessed days also reported to spend more time playing non-active video games. No differences between these groups were found in other EBRBs. Among those who had reported to play active video games during the recorded days, active video game time was positively yet weakly associated with TV/DVD time and snack consumption. Active video game time was not significantly associated with other activities and sugar-sweetened beverages intake. These results suggest that it is unlikely that time spent by adolescents in playing active video games replaces time spent in other physically active behaviors or sedentary activities. Spending more time playing active video games does seem to be associated with a small in intake of snacks, suggesting that interventions aimed at increasing time spent on active video gaming may have unexpected side effects.

Part 2: Analysis of determinants of engaging in game behaviors

Chapter 4 presents a focus group study among adolescent gamers to explore adolescents' views on active and non-active gaming and potential correlates of active gaming and non-active gaming. The specific aims were to explore adolescents' reasons for playing active and non-active games (aspects liked/not liked, preference for active or non-active games, prerequisites for long-term engagement) and the context of active and non-active gaming (when do you play, with whom, rules and restrictions at home). Six focus groups were conducted with adolescents (12–16 years old) representing a range of education levels. A semi structured question route was used containing questions about perceptions and the context of gaming. Results showed that the adolescents had positive attitudes toward active video gaming, especially the social (i.e. playing with others) and the interactive aspect, which was greatly appreciated. Adolescents seemed to enjoy non-active video games more than active ones, mainly because of better game controls and more diversity in non-active video games. Active video games were primarily played when there was a social gathering. Few game-related rules and restrictions at home were reported. We concluded that, given the positive attitudes of adolescents and the limited restrictions for gaming at home, active video games might potentially be used in a home setting as a tool to reduce sedentary behavior. However, to make active games as appealing as non-active games, attention should be paid to the quality, diversity, and the long-term appeal of active games, as these aspects are currently inferior to those of traditional non-active games.

The results from chapter 4 informed the cross-sectional survey study described in **chapter 5** among a larger group of adolescents to further study correlates of gaming in a quantitative way. The research aims of this study were to: (1) examine potential personal, social, and game-related correlates of active video gaming in adolescents; and (2) examine potential personal, social, and game-related correlates of non-active gaming in adolescents; and (3) compare the correlates of active gaming with those of non-active gaming. We conducted a survey assessing game behavior and potential personal, social, and game-related correlates among adolescents (12-16 years, N=353) recruited via schools. Overall, this study showed that various factors were associated with active gaming ≥1 h/wk and non-active gaming >7 h/wk. Adolescents who reported more negative attitudes with respect to non-active video games were more likely to play active video games ≥1 h/wk. Further, adolescents who reported more positive attitudes with respect to active video games, were more likely to play active video games ≥1 h/wk. Next, adolescents who reported to have brothers and sisters that play active video games a lot were also more likely to play active video games ≥1 h/wk their selves. On the other hand, adolescents who reported a more positive attitude with respect to playing non-active video games, were more likely to play non-active video games >7 h/wk. Also, adolescents who reported to have brothers and sisters that play non-active video games a lot were more likely to play non-active video games their selves. Habit strength appeared a correlate of both active and non-active video gaming, indicating that both types of gaming are habitual behaviors. Although these results should be interpreted with caution because of the cross-sectional nature of the study, they do provide important preliminary insight in factors that should be taken into account when developing interventions that aim for replacing non-active gaming by active gaming among adolescents.

Part 3: Intervention development and evaluation

The findings of part 1 and 2 were used as input for the design of the active video game intervention that is central to part 3. The content of the active video game intervention as well as the design and rationale of a randomized controlled trial to evaluate the intervention, are outlined in **chapter 6**. The intervention consisted of providing a PlayStation Move upgrade package to play the active video games on a PlayStation 3 console in the home of the adolescents. The PlayStation Move uses a handheld motion controller wand, a motion-capture PlayStation Eye camera that tracks the player's position and inertial sensors in the wand that detect its motion. Thus, every movement of the player is mimicked on-screen in the game. The following active video games were provided during the intervention: Sport Champions, Move Fitness, Start the Party and Medieval Moves, Dance Star Party and Sorcery. We included three elements to support continuing active video game play: 1) because variation in video games is important the participants in the intervention group received four active Move video games with different game genres (Sport Champions, Move Fitness, Start the Party and Medieval

Moves) at the beginning of the study and two additional video games (Dance Star Party and Sorcery) after four months; 2) because social and family play is important, we provided two controllers to promote playing together with family and friends; and 3) at each contact moment we explicitly asked and encouraged the participants to substitute non-active gaming with active gaming as much as possible and for at least one hour per week. One hour per week corresponds to approximately 70 kcal (which is equivalent to the energy imbalance that can result in unnecessary weight gain) and was regarded as a feasible change.

Chapter 7 presents the results of this randomized controlled trial. Effects of and adherence to the active game promotion intervention on anthropometrics, sedentary screen time and consumption of sugar-sweetened beverages and snacks among gaming adolescents are reported who primarily were of healthy weight. We assigned 270 gaming (i.e. ≥2 hours/week non-active video game time) adolescents randomly to an intervention group (n=140) (receiving active video games and encouragement to play) or a waiting-list control group (n=130). The control group decreased significantly more than the intervention group on BMI-SDS and sum of skinfolds. The intervention group had a significantly higher decrease in self-reported non-active video game time and total sedentary screen time than the control group. The process evaluation showed that 14% of the adolescents played the Move video games every week ≥1 hour/week during the whole intervention period. Thus, the active video game intervention did not result in lower values on anthropometrics in a group of 'excessive' non-active video gamers (mean ~ 14 hours/week) who primarily were of healthy weight compared to a control group throughout a ten-month-period. Even some effects in the unexpected direction were found, with the control group showing lower BMI-SDS and skin folds than the intervention group. The intervention did result in less self-reported sedentary screen time, although these results may be biased by social desirability.

General discussion

The general discussion presented in **chapter 8** integrates the findings of all studies and provides directions for future research and implications for practice. Overall, the findings from this thesis show that active video games seem a promising activity because of a high and broad reach of adolescents and a positive attitude of adolescents towards active games. However, many adolescents did not considered active video games as an attractive replacement of non-active video games. Also, findings suggested that playing non-active games was a habitual behavior. Hence, encouraging adolescents to replace their non-active gaming by active gaming seems not an easy task. In line, our intervention, consisting of providing active video games to adolescents who already played non-active games, did not result in a substantial active game play time and did not contribute to the prevention of overweight.

Because the level of sustained engagement in active gaming was low, future research should examine which factors can enhance participation. Simply providing an active game seems not enough to result in sufficient active game play and increase physical activity. Should the active games be embedded in a structured program for example at schools? Does integrating a competition or cooperation element contribute to increased active game time? Are active games more promising in other target groups? How can we achieve that active games hook people in the same way that non-active games do? Do we need new (better) active games? Our study results indicate that there is need for a new generation of active games to be able to compete with non-active games. Active video games may need to incorporate features that are more aligned to relevant principles that are used in non-active games. Multidisciplinary collaboration (e.g. game designers, health professionals, behavior change experts) is recommended to further develop and apply a comprehensive set of principles for best practice of active games. Smart phones and new technologies such as GPS, wearable sensors, but also virtual reality glasses (e.g. Oculus Rift) provide many opportunities to bring active games a step further.

General conclusions

Video games are an integral and important part of adolescent's life. Therefore, it makes sense to find ways to use the popularity of video games for good purposes. Based on this thesis, the following conclusions can be drawn on active video games as a tool to prevent excessive weight gain in gaming adolescents:

- The majority of adolescents play video games and almost half play active video games, but time spend on playing active video games is much lower than on non-active games.
- Both boys and girls play active video games, and especially adolescents attending lower educational school levels play active video games.
- Playing active video games is considered a social activity, as it is played often with friends and brothers and sisters. Further, having other people (brothers/sisters and friends) around you increases the likelihood of playing active games yourself.
- Gaming adolescents do not consider active video games as an attractive alternative for non-active games. Together with the finding that habit strength is an important correlate of actual gaming behavior, it may be hard to replace non-active game time with active game time.
- Playing active video games does not seem to replace other physical activities. We found preliminary indications that playing active video games can result in less sedentary time and non-active game time. The effects of playing active video games on energy intake are unclear yet.
- Providing and promoting active video games to adolescents who already play non-active games does not result in a substantial active game play time and does not contribute to the prevention of overweight.

Future studies are necessary to evaluate which strategies can motivate gaming adolescents to play active video games instead of non-active ones for a substantial and sustained amount of time or whether active video games might be more suitable for other target groups than gaming adolescents. To conclude, when aiming for prevention of excessive weight gain, we do not recommend providing active video games to gaming adolescents in their home with only a light encouragement to play them.

Samenvatting

Algemene inleiding

Overgewicht bij jongeren is de afgelopen decennia substantieel toegenomen en vormt een groot probleem voor de publieke gezondheid. Overgewicht bij jongeren hangt samen met fysieke en psychosociale problemen tijdens hun jeugd, maar het hangt ook samen met grotere gezondheidsrisico's op latere leeftijd. De onderliggende mechanismen van het ontstaan van overgewicht zijn complex. Genetische en hormonale factoren spelen een rol, maar ook gedrags- en omgevingsfactoren, cognitie en motivatie. Eenvoudig gezegd is het ontstaan van overgewicht het gevolg van een langdurige positieve energiebalans. Een positieve energiebalans houdt in dat er meer energie wordt ingenomen (bijvoorbeeld door voedsel) dan dat er verbruikt wordt (bijvoorbeeld door lichamelijke activiteit). Dit leidt tot overmatige gewichtstoename (een grotere gewichtstoename dan dat nodig is voor de normale groei en ontwikkeling) en uiteindelijk tot overgewicht.

Het stimuleren van een hoger energieverbruik en een lagere energie-inname, en daarmee het herstellen van de energiebalans, is een belangrijke manier om bij te dragen aan de preventie van overmatige gewichtstoename en uiteindelijk overgewicht. Belangrijke gedragingen die de energiebalans zowel positief als negatief kunnen beïnvloeden zijn beweeggedrag (zoals sporten, wandelen en fietsen), sedentair gedrag (zittende activiteiten zoals TV kijken en computergames spelen) en eetgedrag (zoals het consumeren van snacks en suikerhoudende dranken). Alhoewel er diverse behandelprogramma's zijn voor overgewicht en obesitas, zijn de resultaten vaak teleurstellend, vooral op de lange termijn. Daarom is het belangrijk om al in een vroeg stadium in te grijpen en te richten op de preventie van overmatige gewichtstoename, overgewicht en obesitas.

De adolescente levensfase is een kritieke periode is voor het ontwikkelen van overgewicht. In deze levensfase verandert er veel qua hoeveelheid en locatie van lichaamsvet. Bovendien als er overgewicht ontstaat tijdens de adolescentie is de kans groot dat dit continueert naar de volwassen levensfase. Kenmerkend voor de adolescentie is het ontwikkelen van een ongezondere leefstijl zoals minder sportdeelname, minder lichamelijke activiteit, meer sedentair gedrag en een hoge consumptie van suikerhoudende dranken en snacks. Adolescenten zijn echter een moeilijke groep om aan te zetten tot

een gezonde leefstijl. Ze hebben vaak nog weinig inzicht in de lange termijn gevolgen van hun gedrag en hebben weinig interesse in gezondheid. Ze ervaren stress door een lage eigenwaarde, hebben een sterke neiging om onafhankelijk te zijn van ouders en leerkrachten, maar zijn juist sterk afhankelijk van hun leeftijdsgenoten en daarmee ook erg ontvankelijk voor groepsdruk. Deze extra uitdagingen hebben er wellicht tot geleid dat er voor deze doelgroep relatief weinig effectieve interventies zijn om overgewicht en obesitas te voorkomen. Om aansluiting te vinden bij deze doelgroep, is het is belangrijk nieuwe en aansprekende methoden in te zetten die inspelen op de behoeften en interesses van adolescenten. Een activiteit die aansluit bij de interesse van veel adolescenten is het spelen van computergames.

Het verminderen van de sedentaire tijd en het verhogen van de lichamelijke activiteit zijn belangrijke doelen in de preventie van overgewicht en obesitas. Een veelbelovende manier om de sedentaire tijd te reduceren zijn zogenaamde beweeggames of actieve computergames. In deze games moeten de spelers bewegingen met het hele lichaam maken om het spel te kunnen spelen (bv. dansen, boksen, tennissen). Als deze beweeggames de niet-actieve games[1] kunnen vervangen zou dit het sedentair gedrag kunnen verminderen en de lichamelijke activiteit verhogen. Het doel van dit proefschrift is om te onderzoeken in hoeverre beweeggames ingezet kunnen worden om sedentair gedrag te verminderen en daarmee overmatige gewichtsstijging onder gamende adolescenten te voorkomen.

Belangrijkste bevindingen

Deel 1: Analyse van gamegedrag

In **hoofdstuk 2** worden de resultaten gepresenteerd van een cross-sectionele vragenlijststudie onder adolescenten om 1) in kaart te brengen hoeveel adolescenten beweeggames spelen en hoeveel tijd ze hier aan besteden en 2) subgroepen te definiëren voor het spelen van niet-actieve computergames en beweeggames.

Van de deelnemende adolescenten rapporteerde 3% dat ze alleen beweeggames speelden, 40% beide type games, 40% alleen de niet-actieve games en 17% meldde helemaal geen computergames te spelen. Adolescenten die beweeggames speelden, deden dat gemiddeld 1,5 dag per schoolweek met een gemiddelde duur van 36 minuten en 1 dag in een weekend met een duur van 42 minuten. De adolescenten die de niet-actieve games speelden, deden dat op gemiddeld 3,3 dagen per schoolweek met een duur van 65 minuten en 1,4 dagen in een weekend gedurende 80 minuten. Adolescenten die een lagere opleiding (VMBO) volgden waren meer geneigd om minimaal 1 uur per week beweeggames te spelen dan adolescenten die een hogere opleiding volgden. Jongens en oudere adolescenten waren meer geneigd om de niet-actieve computergames te spelen voor meer dan 7 uur per week. Kort samengevat liet deze studie zien dat veel adolescenten

al beweeggames speelden, vooral degenen die een lagere opleiding volgen, maar dat de tijdsbesteding nog relatief laag is vergeleken met de tijdsbesteding aan de niet-actieve games. Willen beweeggames een haalbare methode zijn voor gezondheidsbevordering, moeten interventies er wel voor zorgen dat adolescenten meer tijd aan beweeggames in plaats van aan niet-actieve games spenderen.

Hoofdstuk 3, beschrijft een 24-uurs dagboekstudie bij adolescenten die al geregeld beweeggames spelen. Hiermee werd getracht om meer inzicht te krijgen op welke manier het spelen van beweeggames de energiebalans beïnvloedt. Beweeggames kunnen namelijk alleen een positieve rol spelen voor gewichtsbeheersing wanneer het 1) sedentaire activiteiten vervangt, 2) niet in de plaats komt van beweegactiviteiten en 3) niet samenhangt met een hogere energie-inname. Adolescenten met toegang tot beweeggames en die deze games ten minste een uur per week speelden werden uitgenodigd om deel te nemen aan het onderzoek. Over een periode van een maand werden 5 doordeweekse dagen en 2 weekend dagen random gekozen waarop de adolescenten een bericht ontvingen en gevraagd werden een online dagboekje in te vullen over de afgelopen 24 uur. In dit dagboek vulden ze in hoeveel tijd ze hadden besteed aan het spelen van niet-actieve computergames en beweeggames en hoeveel tijd ze hadden besteed aan andere gedragingen die gerelateerd zijn aan de energiebalans (zoals TV kijken en consumptie van suikerhoudende dranken en snacks). De resultaten lieten zien dat de adolescenten die gerapporteerd hadden beweeggames te spelen meer tijd spendeerden aan niet-actieve games vergeleken met adolescenten die geen beweeggames hadden gespeeld. Er werden tussen deze groepen geen andere verschillen gevonden in gedragingen die gerelateerd zijn aan de energiebalans. Vervolgens hebben we in de groep adolescenten die gerapporteerd hadden beweeggames te spelen de associaties met andere gedragingen bekeken. Hier zagen we dat de tijd die ze aan beweeggames besteedden positief samenhing met de tijd die ze besteedden aan het kijken van TV/DVD en het consumeren van snacks. De tijd die de adolescenten aan beweeggames spendeerden hing niet samen met andere activiteiten en ook niet met de consumptie van suikerhoudende dranken. Deze bevindingen suggereren dat het onwaarschijnlijk is dat de tijd die adolescenten besteden aan beweeggames in de plaats komt van de tijd die ze besteden aan beweegactiviteiten. Wel lijkt het spelen van beweeggames samen te hangen met een kleine toename in de consumptie van snacks en meer tv/dvd tijd. Interventies die richten op het stimuleren van het spelen van beweeggames moeten dus waakzaam zijn op mogelijke ongewenste effecten.

Deel 2: Analyse van determinanten van gamen

In **hoofdstuk 4** wordt een focusgroep studie bij gamende adolescenten beschreven. Deze studie had tot doel meer inzicht te krijgen in de mening van adolescenten over niet-actieve games en beweeggames en welke factoren een rol spelen bij het spelen van

computergames. Hiervoor hebben we zes focusgroepen uitgevoerd met adolescenten (12-16 jaar oud) van diverse opleidingsniveaus. Er werd een semigestructureerd interviewleidraad gevolgd met vragen over percepties en de context van gamen. De resultaten lieten zien dat adolescenten een positieve attitude hadden ten aanzien van beweeggames en dat vooral het sociale aspect (het spelen met anderen) en het interactieve element van beweeggames werd gewaardeerd. Adolescenten gaven aan de niet-actieve games leuker te vinden dan de beweeggames, vooral vanwege de betere besturing en een gevarieerder aanbod in games. Beweeggames werden vooral gespeeld wanneer mensen langs kwamen of tijdens een feestje. Er werden maar weinig regels of beperkingen van de ouders/verzorgers rondom gamen genoemd. Hiermee lijkt het dus dat beweeggames de potentie hebben om ingezet te worden in een thuis setting als een 'tool' om sedentair gedrag te verminderen. Echter de kwaliteit, de variatie en de lange termijn aantrekkelijkheid van beweeggames behoeven nog wel aandacht om te kunnen concurreren met de traditionele niet-actieve games.

De resultaten van hoofdstuk 4 zijn gebruikt als input voor de cross-sectionele vragenlijststudie onder een grotere groep adolescenten om zo ook op een kwantitatieve manier te onderzoeken welke factoren samenhangen met gamen (**hoofdstuk 5**). De specifieke doelen van deze studie waren om 1) de persoonlijke, sociale en computergame-gerelateerde correlaten van beweeggamen en niet-actief gamen te onderzoeken en 2) de correlaten van beweeggamen te vergelijken met die van niet-actief gamen. Hiervoor hebben we een vragenlijststudie uitgevoerd onder adolescenten (12-16 jaar, N=353), die we geworven hadden via middelbare scholen. Samengevat liet deze studie zien dat verschillende factoren samenhangen met beweeggamen (≥1 uur per week) en niet-actief gamen (>7 uur per week). Adolescenten die een negatievere attitude hadden ten aanzien van niet-actieve games hadden een grotere kans om beweeggames (≥1 uur per week) te spelen. Adolescenten met een positievere attitude ten aanzien van beweeggames hadden een grotere kans om beweeggames te spelen (≥1 per week). Daarnaast hadden adolescenten met broers en zussen die veel beweeggames games speelden een grotere kans om beweeggames te spelen (≥1 uur per week). Anderzijds, hadden adolescenten met een positievere attitude ten aanzien van niet-actieve games een grotere kans om de niet-actieve games te spelen voor >7 uur per week. Ook adolescenten met broers en zussen die veel niet-actieve games spelen hadden grotere kans om zelf niet-actieve games te spelen (>7 uur per week). De mate waarin gamen een gewoontegedrag was hing samen met zowel beweeggamen als niet-actief gamen, wat er op lijkt te duiden dat beide vormen van gamen gewoonte gedragingen zijn. Het moet opgemerkt worden dat de resultaten voorzichtig geïnterpreteerd moeten worden omdat het een cross-sectionele studie was en er dus bijvoorbeeld geen oorzaak gevolg conclusies kunnen worden getrokken. De resultaten geven echter wel een belangrijk eerste inzicht in welke factoren van belang zijn om rekening mee te houden wanneer men een interventie ontwikkelt die gericht is op het vervangen van niet-actief gamen door beweeggamen bij adolescenten.

Deel 3: Ontwikkeling en evaluatie van een beweeggame interventie

De bevindingen uit de eerste twee delen zijn gebruikt voor het ontwikkelen van de beweeggame interventie. De inhoud van de beweeggame interventie, het design en de rationale van de gerandomiseerde gecontroleerde trial (RCT) om de interventie te evalueren zijn beschreven in **hoofdstuk 6**. De interventie bestond uit het beschikbaar stellen van een PlayStation Move startpakket waarmee de adolescenten thuis beweeggames op hun PlayStation 3 console konden spelen. De PlayStation Move gebruikt een controller met bewegingssensor die de speler in de hand moet houden. Een bewegingssensor in de PlayStation Eye camera detecteert de bewegingen van de speler en de bewegingen van de controller. Hiermee wordt elke beweging van de speler geregistreerd en vertaald naar het spel op het scherm. De deelnemers kregen zes beweeggames mee: Sport Champions, Move Fitness, Start the Party and Medieval Moves, Dance Star Party and Sorcery. Om het gebruik van de beweeggames te stimuleren zorgden we voor vernieuwing en variatie in gamegenre bij het aanbieden van de beweeggames. Bij aanvang kregen ze vier beweeggames en na vier maanden kregen ze twee nieuwe beweeggames erbij. Er werden twee controllers meegeleverd om het samen spelen te stimuleren en hiermee werd dus ingespeeld op het zo gewaardeerde sociale aspect van beweeggames. Tot slot werden de deelnemers bij ieder contactmoment gevraagd en aangemoedigd om de beweeggames ten minste een uur in de week te spelen, maar het liefst zo veel mogelijk en dit in de plaats van de niet-actieve games te doen. Het uur per week was gebaseerd op een berekening die liet zien dat je met een uur beweeggamen in plaats van niet-actief gamen een energie disbalans van 70 kcal kan herstellen. Daarnaast kan een uur per week ook als een haalbare verandering beschouwd worden kijkend naar de gevonden tijdsbesteding van adolescenten aan beweeggamen en niet-actief gamen zoals beschreven in hoofdstuk 2.

Hoofdstuk 7 beschrijft de resultaten van de (RCT) bij gamende adolescenten waarvan de meerderheid een gezond gewicht had. In deze RCT zijn de effecten van de interventie onderzocht op antropometrie (lengte, gewicht, buikomvang, heupomvang en huidplooidikte), sedentair gedrag en de consumptie van suikerhoudende dranken en snacks. Ook is een uitgebreide procesevaluatie uitgevoerd waarin geëvalueerd is in welke mate de adolescenten zich hadden gehouden aan de interventie en hoe ze de beweeggames waardeerden. Voor deze studie werden 270 gamende adolescenten (≥2 uur per week niet actief gamen) at random onderverdeeld in een interventiegroep die werd blootgesteld aan de interventie zoals beschreven in hoofdstuk 6 (n=140) of een controlegroep die na afloop van het onderzoek het PlayStation Move starterspakket kreeg (n=130). De resultaten lieten zien dat de Body Mass Index gecorrigeerd voor gemiddelde standaarddeviatiescores (BMI-SDS) en de huidplooidikte in de controlegroep significant meer afnam dan in de interventiegroep. De tijd die de adolescenten aan niet-actieve games besteedden en de totale tijd die ze besteedden aan sedentaire activiteiten nam meer af in

de interventiegroep dan in de controlegroep. De procesevaluatie liet zien dat, bekeken over de gehele interventieperiode van 10 maanden, 14% van de adolescenten in de interventiegroep de Move games voor tenminste een uur in de week speelden. Concluderend bleek de beweeggame interventie dus niet te leiden tot lagere antropometrische waarden in een groep excessief gamende adolescenten (gemiddeld ~ 14 uur per week), waarvan de meerderheid een gezond gewicht had, vergeleken met een controlegroep. Er werden zelfs wat effecten in onverwachte richting gevonden, aangezien de controlegroep een lagere BMI-SDS en huidplooidikte liet zien dan de interventiegroep. De beweeggame interventie leidde wel tot minder beeldscherm gerelateerd sedentair gedrag, maar aangezien dit gebaseerd was op zelfrapportage zouden deze resultaten beïnvloed kunnen zijn door sociale wenselijkheid.

Algemene discussie

In de algemene discussie in **hoofdstuk 8** worden de resultaten van alle studies in dit proefschrift geïntegreerd en worden aanbevelingen voor verder onderzoek en de praktijk gegeven. Over zijn geheel laat dit proefschrift zien dat beweeggames veelbelovend lijken vanwege het grote en brede bereik van de beweeggames en de positieve attitude van adolescenten ten aanzien van beweeggames. Echter, het laat ook zien dat adolescenten beweeggames niet zien als een aantrekkelijk alternatief voor de niet-actieve computergames. Ook lijkt gamen een gewoontegedrag, wat het veranderen van dit gedrag lastig maakt. Deze bevindingen geven aan dat het nog wel lastig kan zijn om adolescenten beweeggames te laten spelen in plaats van niet-actieve computergames. De interventiestudie bevestigde dit, aangezien de resultaten lieten zien dat de beweeggame interventie er niet toe leidde dat de adolescenten substantiële tijd besteedden aan het spelen van de beweeggames en niet bijdroeg aan de preventie van overmatige gewichtstoename.

Het duurzaam gebruik van de beweeggames was erg laag, dus verder onderzoek is nodig om er achter te komen welke factoren duurzaam gebruik van beweeggames kunnen stimuleren. Alleen het aanbieden van beweeggames en een lichte aanmoediging om ze te spelen lijkt niet voldoende om gamende adolescenten regelmatig en duurzaam beweeggames te laten spelen en zo overmatige gewichtstoename te voorkomen. De volgende vragen moeten in verder onderzoek nog beantwoord moeten worden om dit onderzoeksgebied een stap verder te brengen. Moeten beweeggames ingebed moeten worden in een gestructureerd programma, bijvoorbeeld via scholen, om zo een groter gebruik van de games te bewerkstelligen? Zou een competitie element kunnen bijdragen aan meer gebruik van de beweeggames? Zijn er andere en betere beweeggames nodig om een bijdrage te kunnen leveren aan de preventie van overgewicht? Wat is er nodig om ervoor te zorgen dat beweeggames net zo'n grote aantrekkingskracht hebben op adolescenten als de niet-actieve computergames? Zouden beweeggames meer aanslaan bij andere doelgroepen?

Om beter te kunnen concurreren met de niet-actieve games zouden beweeggames wellicht meer kenmerken en principes van de niet-actieve computergames moeten incorporeren. Meer multidisciplinaire samenwerking (gamedesigners, gezondheidsprofessionals, gedragsveranderingsexperts etc.) is aanbevolen om zo aantrekkelijkere en effectievere beweeggames te ontwikkelen. Daarnaast bieden Smartphones en nieuwe technologie als GPS, draagbare sensoren ('wearables') en Virtual Reality brillen (bijv. Oculus Rift) nieuwe mogelijkheden om de aantrekkingskracht en effectiviteit van beweeggames een stap verder te helpen.

Algemene conclusie

Gebaseerd op dit proefschrift kunnen de volgende conclusies getrokken worden ten aanzien van de rol die beweeggames kunnen spelen bij de preventie van overmatige gewichtstoename bij gamende adolescenten:

- De meerderheid van adolescenten speelt computergames en bijna de helft speelt beweeggames. De tijd die adolescenten besteden aan beweeggames is echter substantieel lager dan de tijd die ze besteden aan niet-actieve computer games.
- Zowel jongens als meisjes spelen beweeggames, en vooral adolescenten die een lagere opleiding volgen spelen beweeggames.
- Beweeggames worden vaak gespeeld met anderen (zoals vrienden, broers en zussen) en het wordt gezien als een sociale activiteit. Het hebben van mensen in je omgeving die veel beweeggames spelen verhoogt ook de kans om zelf beweeggames te spelen.
- Gamende adolescenten zien beweeggames niet als een aantrekkelijk alternatief voor niet-actieve computergames. Daarnaast lijkt gamen een gewoontegedrag. Deze bevindingen geven aan dat het lastig kan zijn om adolescenten beweeggames te laten spelen in plaats van niet-actieve computergames.
- Er zijn aanwijzingen gevonden dat het spelen van beweeggames kan leiden tot minder totale sedentaire tijd en minder niet-actief gamen. Ook lijkt het spelen van beweeggames niet in de plaats te komen van andere beweegactiviteiten. De effecten van het spelen van beweeggames op de energie-inname zijn nog niet duidelijk.
- Het aanbieden van beweeggames samen met lichte aanmoediging tot het spelen ervan aan adolescenten die al niet-actieve games spelen leidt niet tot een substantieel gebruik van de beweeggames en draagt niet bij aan de preventie van overmatige gewichtstoename.

Verder onderzoek is nodig om te evalueren welke strategieën er nodig zijn om gamende adolescenten te motiveren om beweeggames voor substantiële tijd te spelen in plaats van niet-actieve computergames. Verder onderzoek is ook aanbevolen om te evalueren of in andere doelgroepen dan gamende adolescenten meer effecten behaald kunnen worden met beweeggames. Conclusie van dit proefschrift is dat het aanbieden

van beweeggames voor thuis gebruik, aan gamende adolescenten, met een kleine aanmoediging voor gebruik er van, geen zin heeft wanneer men zich richt op preventie van overmatige gewichtstoename.

Voetnoot

[1]In dit proefschrift worden de games die je zittend speelt 'niet-actieve (computer) games' genoemd en de games waarbij je moet bewegen worden 'beweeggames' of 'actieve (computer)games' genoemd.