Handbook of Research on Holistic Perspectives in Gamification for Clinical Practice

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Chapter 13
The Effects of Active Videogames on BMI among Young People:
A Meta-Analysis

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ABSTRACT

The objective of this chapter is a systematic review and meta-analysis was performed to quantify the effectiveness of active videogames (AVGs) as obesity prevention interventions aimed at children and adolescents. The method is studies were included that focused on children or adolescents (≤18 years), assessed BMI as the outcome measure, used one or more AVGs as intervention, employed a controlled experimental design, used BMI as an outcome measure, enrolled participants up to and including 18 years of age, and comprised original studies. Employing these inclusion criteria, nine studies were included in the meta-analysis. The results are active videogames had a small to medium-sized and significant average effect on children and adolescents: Hedges' g = 0.38 (95% CI: 0.00 - 0.77). Heterogeneity was substantial (I2 = .91) but neither participants' weight status, nor sample size, intervention duration or dropout moderated the effect of AVGs. The conclusion of this chapter is the results of this meta-analysis provide preliminary evidence that active videogames can decrease BMI among children/adolescents.

INTRODUCTION

For children and adolescents, rigorous physical exercise contributes to a healthy body weight (Must & Tybor, 2005). Promoting exercise is challenging, however, because physical activity has multiple antecedents (Bauman, Sallis, Dzewaltowski, & Owen, 2002). Interventions have generally had small effects (Brawley, Rejeski, & King, 2003; Waters et al., 2011) and have not been able to reverse an alarming increase in obesity rates (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010).

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Therefore, it is critical that we try to identify novel approaches to promoting exercise. In the present chapter, we investigate whether so called active videogames (AVGs) are an effective instrument to promote exercise among children and adolescents.

AVGs are defined as "interactive video or electronic games that feature player movement, such as would occur in 'real-life' exercise participation" (Bailey & McInnis, 2011). In AVGs players can control avatars, obtain points and/or move the game's narrative along by moving (parts of) their bodies. Usually, players' movements are recorded by floor mats, infra-red cameras, or other devices, and serve as input in the game (e.g., *Dance Dance Revolution*TM and *Wii Sports Resort*TM). Many of these games require considerable physical exertion to play the game, and hence are often denoted as 'active videogames' (LeBlanc et al., 2013) or 'exergames' (Larsen, Schou, Lund, & Langberg, 2013).

An example of a particularly popular and commercially successful AVG is *Dance Dance Revolution*™, in which players enter a virtual dancing contest. In *Dance Dance Revolution*™, players stand on a 'dance pad' while looking at a screen and listening to music. The dance pad contains colored arrows laid out in a cross, and the gameplay entails that players step on these arrows, timing their steps both to the rhythm of the music that is played and to arrows that appear on the screen. These on-screen arrows appear at the bottom of the screen and move upwards, passing over the 'Step Zone' near the top. When the moving arrows overlap with the Step Zone, the player must step on the dance pad arrows that correspond with the moving arrows on the screen. The game judges every step in terms of accuracy (from 'miss' to 'marvelous'). Accurate steps fill the life bar, but inaccurate steps drain it. A fully depleted life bar means 'game over'. Otherwise, the player is taken to the Results Screen, which rates the player's performance. Receiving a passing score means that players will be allowed to choose another song and continue to play.

It has been repeatedly shown that active videogames such as *Dance Dance Revolution*™ can result in increased physical activity, as well as related health-outcomes (Bethea, Berry, Maloney, & Sikich, 2012; Maddison et al., 2011). On the other hand, several studies have found the effect of AVGs to be non-significant (Madsen, Yen, Wlasiuk, Newman, & Lustig, 2007; Wagener, Fedele, Mignogna, Hester, & Gillaspy, 2012). The effects of AVGs among young people has been the subject of several systematic reviews (Biddiss & Irwin, 2010; LeBlanc et al., 2013; Lu, Kharrazi, Gharghabi, & Thompson, 2013; Peng, Lin, & Crouse, 2011). Importantly, conclusions in these reviews were based on statistical significance (i.e., *p*-values). This may not be surprising in light of the important role that *p*-values have traditionally played in behavioral science. Recently, however, scholars have increasingly stressed the importance of effect sizes, because these, unlike *p*-values, can be used if we want to estimate the substance and meaningfulness of the effect (Kline, 2004; Volker, 2006). With regards to the 'robustness' of these effect sizes, it has been argued that confidence intervals are more informative than p-values (Cumming, 2013). In this paper, we therefore report effect sizes and use these in a meta-analysis to be able to obtain an estimate of how meaningful and substantial the effects of AVGs actually are.

To our knowledge, only two studies employed meta-analytic procedures to assess AVGs' effects. One study meta-analyzed 18 studies on the effects of AVGs on acute energy expenditure. The results of this study showed that AVGs do indeed facilitate light- to moderate-intensity activity (Peng et al., 2011). This meta-analysis, however, did not assess whether AVGs can result in increased physical activity in the long run, which, one could argue, is more relevant than single-session physical exertion (LeBlanc et al., 2013). Nor did it focus on obesity-related outcomes, such as BMI. A second study did investigate the long-term effects of AVGs and focused on BMI as the primary outcome measure (Van't Riet, Crutzen, & Lu, 2014). This study meta-analyzed the results of five studies that tested the effect of AVGs on BMI and found a non-significant composite effect size of Hedges $g = 0.20$ (95% confidence interval: 95% CI: -0.08 - 0.48). Based on this positive, but small, effect size, the authors conclude that AVGs, while not a silver bullet, can contribute positively to obesity prevention.

Since this study (Van't Riet et al., 2014) has been conducted, several new studies have appeared that would have met the original inclusion criteria (Staiano, Abraham, & Calvert, 2013; Trost, Sundal, Foster, Lent, & Vojta, 2014; Wagener et al., 2012). Therefore, a new meta-analysis would likely result in a new, probably more robust, estimate of the effectiveness of AVGs. We therefore conducted an updated meta-analysis and report the results in the present chapter.

Research on AVGs is still in its infancy (Lu et al., 2013) and it is probably too early to arrive at a definitive conclusions regarding their effectiveness. Nevertheless, it is important to obtain a quantified preliminary estimate of AVGs' effects on BMI and/or other relevant health outcomes in a 'considered synthesis of multiple studies' (Sutton & Higgins, 2008, p. 626). In this study, therefore, we used meta-analytic procedures to provide an estimate of the effectiveness of active videogames.

BACKGROUND

Physical exercise is an important part of many prevention and treatment programs in health care. In fact, 'exercise on prescription' schemes have been proposed as complementary to, and sometimes as alternatives for, traditional medicine (Thurston & Green, 2004). A problem with conventional exercise training is that it is often repetitive and monotonous, as a result of which patients lose interest and drop out (Najafi, 2013). In fact, one study found that around half of people who enrolled in an exercise program gave up in the first 6 months (Robison & Rogers, 1994). It has been noted that, in elderly care, where exercise is often of paramount importance to maintain balance and other aspects of physical function, outcomes could be improved if exercise programs provided more fun and enjoyment (Jacobs, Timmermans, Michielsen, Van der Plaetse, & Markopoulos, 2013; Thurson & Green, 2004). Several scholars have investigated whether adherence to exercise programs can be improved by 'gamifying' elements of the program (Jacobs et al., 2013; Najafi, 2013: Zuckerman & Gal-Oz, 2014).

Gamification has been defined as 'the use of game design elements in non-game contexts' (Deterding, Dixon, Khlaled, & Nacke, 2011), or more elaborately as 'a process of enhancing a service with [..] affordances for gameful experiences in order to support the user's overall value creation' (Huotari & Hamari, 2012). An important feature of gamification is the fact that it does not refer to designing new games, but rather to taking an existing system, and adding elements of 'gamefulness' to it (Hamari & Koivisto, 2013).

One example of gamifying exercise programs is to incorporate existing AVGs in interventions. As described above, AVGs are digital gaming systems in which players can control avatars, obtain points and/or move the game's narrative along by moving (parts of) their bodies, mostly requiring considerable physical exertion to play the game. In a gamification approach to exercise programs, the AVG constitutes the 'game-design element' that is incorporated into the 'non-game context' of the exercise program. It is important to note that most interventions in this domain do not develop their own AVG, but rather take an existing (commercial) AVG to be used in the intervention (Larsen et al., 2013). Studies in elderly care have shown that this approach can be highly effective. Pichierri et al. (2012), for instance, tested an exercise program that made use of a dance videogame and found that this intervention resulted in improved balance in their elderly participants. The present chapter aims to establish how effective AVGs are as an obesity-prevention intervention for young people.

Exercise programs for young people usually take the form of having participants enroll in formalized and supervised activities. One accepted way of doing this is to simply increase the number of physical activity classes in children's school curriculum. In one study using this approach, the extra classes were supervised by children's regular physical activity teachers and had similar content as the standard lessons in the curriculum (Linden et al., 2006). In another study, a school-based intervention consisted of 90 minutes per week of supervised exercise and an additional weekly hour of free use of the exercise facilities. The intervention also entailed classes on physical activity and diet (Blüher et al., 2014). In principle, many of these formalized exercise programs could benefit from some degree of gamification. For instance, one study examined a novel exercise program in a summer camp setting, where children engaged in 4 hours per day of supervised, play-based physical activity. The emphasis was on exploring, learning new skills and fun (Meucci et al., 2013).

With increasing degrees of gamification, exercise programs can still be implemented as formalized and supervised interventions. As an example of this, Gao et al. (2013) implemented an exercise program in the class room, enrolling children in three 30-minute sessions of AVG-based exercise. However, exercise programs can also be designed to engage the participant's curiosity and intrinsic motivation in a freer, more independent, setting. Maddison et al. (2011), for instance, implemented their intervention by sending participants the hardware and software to play AVGs at home. Thus, by gamifying exercise programs, it could be possible to rely on children's desire for play, rather than designing and implementing elaborate formalized interventions. Additionally, there is at present no reason to suspect that AVGs lead to a fundamentally different kind of exercise. At least, research shows that AVGs enable strenuous physical exercise, allaying fears that AVG-based exercise is less intensive that the traditional kind (Peng et al., 2011).

Gamification thus seems to hold great promise for exercise promotion. Before recommending gamification as an intervention tool, however, we need to know that it is effective. As discussed in the previous section however, the evidence in this regard is inconclusive and there is a need for a thorough quantitative synthesis of the available data. In the present chapter, we therefore present the results of a meta-analysis on the effectiveness of AVGs as exercise interventions for young people.

METHOD

Data Sources

To identify eligible studies, the following search string was employed on 27 June 2014 to search for publications on *Google Scholar*: bmi AND activ* AND ("active videogame" OR "active video game" OR exergame) AND (child* OR young OR adolescen*) AND (RCT OR randomized OR experiment*). This yielded 309 results. The criteria for inclusion in the present meta-analysis were:

1. One or more AVGs were used as the intervention,
2. The effects of the AVG were compared with a control group in a randomized study,
3. Employment of BMI as an outcome measures,
4. Study must not target participants over 18 years old, and
5. Original study only.

As a first step in the selection process, EA investigated the title and abstract of each manuscript and selected 32 manuscripts that potentially complied with these inclusion criteria. When in doubt, the paper was retained for the second step. In this second step, EA and JvtR investigated the full texts of these 32 manuscripts and ultimately selected seven studies that complied with all criteria. These seven studies were included in the present meta-analysis. The same procedure was used with a Web of Science search, but this yielded no additional included studies. After the literature search, the reference lists of four recent systematic reviews (Biddiss & Irwin, 2010; LeBlanc et al., 2013; Lu et al., 2013; Peng, Crouse, & Lin, 2013; Van't Riet et al., 2014) were investigated to identify possible studies that would satisfy our inclusion criteria. This yielded two additional studies (Mhurchu et al., 2008; Murphy et al., 2009).

Study Characteristics

We coded all studies with regards to intervention characteristics that could potentially affect the effect of the intervention. We coded intervention duration (in weeks) and frequency (number of sessions per week). In addition, we coded whether the AVG was designed specifically to affect health-related outcomes among young people or whether the game was commercially available. The latter variable was assessed because it has been suggested that commercial AVGs may hold great promise for health promotion, as they are generally affordable and accessible, while at the same time more technologically advanced than videogames developed by not-for-profit organizations or by researchers (Lange, Flynn, & Rizzo, 2009). Participants' weight status was also recorded, as was sample size and the nature of the control group.

Effect Size Measures

The outcome measure of interest in the present meta-analysis was BMI (including percentiles and z-scores). Each study yielded a comparison between an AVG and a control condition. This comparison was expressed with the standardized mean difference. Hedges' g was used, because it yields a more accurate estimate of the effect size than Cohen's d in small samples (i.e., Cohen's d is slightly biased towards overestimating the standardized mean difference in small samples) (Borenstein, Hedges, Higgins, & Rothstein, 2009). Conventionally, effect sizes of $g = 0.20$, $g = 0.50$, and $g = 0.80$ are considered small, medium, and large, respectively (Cohen, 1988). The data were coded such that a positive g indicates a positive intervention effect. Effect-sizes were computed from reported means, SDs, and Ns for the post-test comparisons. In one case (Mhurchu et al., 2008), means, SDs, and Ns were requested from the authors.

Data Analysis

Analyses were run using both a fixed-effect model and a random-effects model (Borenstein et al., 2009). We calculated the within-class goodness-of-fit statistic Q as an estimate of the homogeneity in the true effect sizes across studies (Hedges & Olkin, 1985; Hedges & Vevea, 1998). Q is approximately chi-square distributed, with $df = k - 1$, where k is the number of effect sizes). A significant Q statistic signifies large heterogeneity in the true effects. This means that the variability in effect sizes across studies can at least partly be explained by moderator variables. We also calculated the I^2 statistic, because of the low power of the Q statistic when using few studies (Higgins, Thompson, Deeks, & Altman, 2003). The I^2 statistic can be interpreted as the proportion of total variability explained by heterogeneity (Higgins et al., 2003). In case of large heterogeneity, we performed moderator analyses with the coded intervention and study characteristics. We tested for categorical moderators with the categorical model test (Hedges & Olkin, 1985), which results in the between-class goodness-of-fit statistic QB, with $df = j - 1$ (where j is the number of categories or groups). A significant between-groups effect indicates that the moderator at least partly explains the variance in effect-sizes. Weighted least square regression of the effect sizes onto the continuous moderator (Card, 2012; Lipsey & Wilson, 2001) was performed to test for continuous moderators. It is worth mentioning, however, that moderator analyses in meta-analysis do not always have high power (Hedges & Pigott, 2004). In fact, a large number of studies is generally needed to detect significant moderator effects (Hempel et al., 2013). Given that research about AVGs is still young, and that there are not many published studies (Lu et al., 2013), the results of these analyses should be considered with caution. Formal tests of publication bias (e.g., examining funnel plots) are generally only recommended when more than 10 effect sizes are available for analysis (Sterne et al., 2011), and therefore were not performed for the present study. We analyzed the data with RevMan (RevMan, 2008) and with an Excel spreadsheet. The spreadsheet can be found at https://osf.io/t45xh/.

Results

Nine studies were included in the analysis, in total enrolling 760 participants (see Table 1). An analysis using a fixed-effect model revealed an effect size of $g = 0.29$ (95% CI: 0.15 - 0.44). This effect was significant and small to medium-sized. Employing a random-effects model yielded an effect size of $g = 0.38$ (95% CI: 0.00 - 0.77). This effect was also significant, and small to medium.

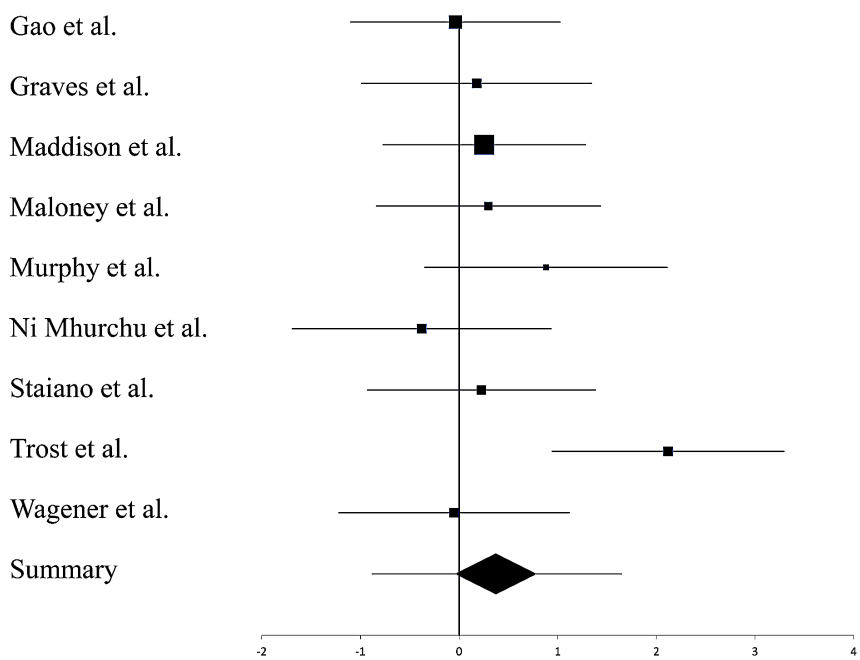
A forest plot for the random-effects model is shown in Figure 1. Note that the composite effect size is represented by a diamond, with the width of the diamond indicating the 95% confidence interval (i.e., we can be 95% certain that our mean effect size falls within this range) and with the horizontal line indicating the prediction interval (i.e., we estimate that the true effect in 95% of future studies will fall within this range) (Borenstein et al., 2009).

The Q statistic was significant effect, $Q(8) = 43.96$, $p < .001$, meaning that heterogeneity was substantial. The I^2 statistic revealed that systematic differences between studies were responsible for a large part (91%) of the variance in effect sizes across studies ($I^2 = .91$) (Higgins et al., 2003), indicating that a far larger share of the variance in effect sizes across studies could be attributed to moderator variables rather than to sampling error. For this reason, we performed moderator analyses.

Table 1. Sample sizes, effect sizes, and study characteristics for the included studies

	Study	N	g	Duration (Wks)	Frequency (Session/ Wk)	Off-the-Shelve Game	Control Condition	Participant Weight Status	Dropout (%)
1	Gao et al.,(2013)	126	-0.04	36	3	Yes	No treatment	No weight requirements	22
2	Graves et al. (2010)	42	0.18	12	n.a.	Yes	No treatment	No weight requirements	39
3	Maddison et al. (2011)	322	0.25	24	n.a.	Yes	No treatment	Overweight/ obese	20
4	Maloney et al. (2008)	58	0.30	10	n.a.	Yes	No treatment	No weight requirements	10
5	Murphy et al. (2009)	35	0.88	12	n.a.	Yes	No treatment	Overweight/ obese	0
6	Ni Mhurchu et al. (2008)	20	-0.38	12	n.a.	Yes	No treatment	No weight requirements	0
7	Staiano et al. (2013)	54	0.23	20	5	Yes	No treatment	Overweight/ obese	27
8	Trost et al. (2014)	63	2.12	16	n.a.	Yes	Regular treatment	Overweight/ obese	8
9	Wagener et al. (2012)	40	-0.05	10	3	Yes	No treatment	Obese	2

Figure 1. Forest plot of the included effect sizes



It was not possible to use all study characteristic as moderators in the analyses. As can be seen in Table 1, several of the categorical moderator variables showed very little variation between studies: all studies employed commercially available videogames and all but one compared an active videogame condition with a no-treatment control condition. For intervention frequency, insufficient information was available. For the remaining variables, moderator analyses revealed that the effect size in studies that recruited participants of all weights did not differ significantly from the effect size in studies that recruited only overweight and/or obese participants, $Q(1) = 2.21$, $p = .14$. Additionally, sample size, $\beta = -0.12$, $t(8) = -0.01$, $p = .98$, intervention duration (in weeks), $\beta = -0.29$, $t(8) = -1.94$, $p = .09$, and dropout, $\beta = -0.27$, $t(8) = -1.90$, $p = .09$, had non-significant effects.

DISCUSSION

The present study aimed to synthesize the existing research on the effectiveness of AVGs for obesity prevention in children and adolescents. A small to medium-sized positive effect of AVGs on children's BMI (Hedges' $g = .38$) was found, suggesting that AVGs can be a helpful tool in decreasing BMI among youth. Previously, systematic reviews have not been able to draw firm conclusions about the effects of AVGs, because individual studies have shown mixed results. Lu et al. (2013) for instance, did not address the overall effectiveness of AVGs. Another recent systematic review (LeBlanc et al., 2013) did find effects of AVGs on immediate energy expenditure, but concluded that there is insufficient evidence to suggest that AVGs result in long-run positive effects for health. The preliminary estimate provided by the present meta-analysis suggests that AVGs have positive effects with regards to children's BMI on the short-to-medium term (intervention duration ranged from 10 to 36 weeks; see Table 1).

The estimate of AVGs' effect that is provided by the present meta-analysis can be regarded as a first, preliminary estimate. This estimate will likely be updated as more randomized effectiveness studies become available. At present, AVG research is still in its infancy, and only a limited number of studies could be included in the meta-analysis (k = 9). It should be noted that our relatively small sample poses limits on the conclusions that can be drawn. For one, the power to find significant effects in moderator analyses is low when the set of studies is small (Hedges & Pigott, 2004; Hempel et al., 2013). In addition, the estimate of the between-studies variance can be imprecise, which compromises the precision of random-effects models (Borenstein et al., 2009). The value of the I^2 statistic suggested that 91% of the variance in effect sizes across studies was attributable to systematic differences. This suggests that the extent to which studies could be compared was limited, even though our inclusion criteria resulted in similar populations (youth aged 12-18) and similar interventions (AVGs) across studies. However, because the statistical power of meta-analyses depends on the number of studies, and not on the number of total participants (Hedges & Pigott, 2004; Hempel et al., 2013), our moderator analyses likely did not have sufficient power to detect small and medium-sized moderation effects. Future meta-analyses will hopefully be better equipped to investigate which factors moderate the effectiveness of AVGs.

In sum, for children and adolescents, AVGs can serve as effective exercise programs. Changes in BMI were observed regardless of participants' prior weight status, which suggests that AVGs can be applied both in the prevention and in the treatment of obesity.

But why were AVGs successful in lowering BMI? From a purely physiological perspective, one could say that, all other things being equal, playing AVGs lead to more burnt calories than not playing AVGs. Also, all other things being equal, higher game-play frequency (in terms of occasions of play per week), longer game-play duration (in terms of minutes per occasion) and longer game-play maintenance (in terms of sustained regular play over time) will likely result in more weight loss and /or more effective weight gain prevention. However, this is the case for all exercise programs and, as noted above, most regular exercise programs suffer from high attrition rates. The effectiveness of AVGs thus most likely lies in their ability to motivate children and adolescents to play and keep playing. Unfortunately, we only encountered one study that compared an AVG-based intervention with a traditional exercise program (Trost et al., 2014). The large effect size in this study (g = 2.20) suggests that AVGs are more effective in motivating and enabling participants to continue their exercise than traditional exercise programs. More research is necessary, however, to corroborate this hypothesis.

FUTURE RESEARCH DIRECTIONS

The failure to find significant moderators of AVGs' effectiveness is disappointing for those who want to know which factors render an AVG especially likely to be effective. What is more, the nine included studies themselves provide very little information on what makes AVGs effective. When taking a close look at the nine studies that were included in the present meta-analysis, it is striking that so few studies included process measures alongside outcome measures (see Table 2). That is, all nine studies assessed BMI and in some cases other health-related outcomes, but only five studies assessed long-term habitual physical activity during the interventions. What is more, Table 2 shows that only two studies reported the effects of the intervention on psychosocial variables. One of these studies showed that AVG-play resulted in increased self-efficacy with

Table 2. Outcome measures and process measures in the included studies

	Study	Health/Fitness	PA	Psychosocial/ Motivational	Other
1	Gao et al. (2013)	BMI, fitness test (1-mile run)	-	-	Academic achievement
2	Graves et al. (2010)	BMI, maturity status, body fat	Habitual PA assessment	-	Active and sedentary behaviours other than AVG play
3	Maddison et al. (2011)	BMI, waist circumference, body fat, fitness test (20-meter shuttle test)	Habitual PA assessment	-	All videogame play, snacking behaviour
4	Maloney et al. (2008)	BMI	Exertion during AVG-play	-	-
5	Murphy et al. (2009)	BMI, blood pressure, blood chemistry, fitness test (ramped protocol on ergometer)	-	-	-
6	Ni Mhurchu et al. (2008)	BMI	Habitual PA	-	All videogame play, estimated time spent in various activities,
7	Staiano et al. (2013)	BMI	-	Self-efficacy, self-esteem, peer support	-
8	Trost et al. (2014)	BMI	Habitual PA assessment	-	-
9	Wagener et al. (2012)	BMI	-	Perceived competence, psychological adjustment	-

regards to physical activity and increased peer support in general (Staiano et al., 2013). The second study showed increases in perceived competence to exercise and improvements in relations with parents as a result of the AVG intervention (Wagener et al., 2012). In the other seven studies, however, the researchers seemed to be more interested in the question *whether* AVGs work than in the question *how* they work. While this focus on effectiveness is perfectly understandable from a public health perspective, we argue that, to increase our knowledge of the effects of AVGs, and to be able to maximize the effects of future AVG interventions, it is imperative to know more about the underlying mechanisms of AVG effects. With several well-designed studies now published on the effects of AVGs on BMI, and a meta-analysis showing a promising small to medium-sized effect, now is the time to start investigating these underlying mechanisms.

As noted earlier, it is likely that AVGs motivate more and longer-lasting exercise than regular exercise programs. Unfortunately, there is a dearth of research of why this would be the case. Intensity, frequency, duration and maintenance of game-play are all influenced by motivational factors, but future studies should investigate which motivational or psychological factors predict participation. In other words, now that we know that playing AVGs leads to lower BMI, we need to know why children would play AVGs.

According to Self Determination Theory (SDT) (Deci & Ryan, 1985), competence, autonomy and relatedness are individuals' three basic psychological needs. When these needs are satisfied, the result is increased well-being and initiation and maintenance of behavior. Importantly, there is support for the notion that satisfaction of the needs for competence, autonomy and relatedness is highly predictive for the enjoyment of videogames (Tamborini, Bowman, Eden, Grizzard, & Organ, 2010), and also for the notion that these needs are highly important in the decision to engage in physical activity (Edmunds, Ntoumanis, & Duda, 2006; Fortier, Sweet, O'Sullivan, & Williams, 2007).

Competence has been described as a subjective feeling of efficaciousness in dealing with the world and experiencing and expressing personal capacities (Deci & Ryan, 1985). The need for competence is the reason why individuals often seek out situations that require specific abilities, such as games. Autonomy refers to the feeling of being a causal agent in one's own actions and constitutes the opposite of being controlled by others or by circumstances (Deci & Ryan, 1985). People's need for autonomy can be satisfied when videogame players see that they can effectively control an avatar (Rigby & Ryan, 2011). Relatedness is often defined as the sense that one is connected with others in mutually supportive relationships (Baumeister & Leary, 1995). It is related to feelings of secure unity with others and belongingness, and it is clearly distinct from the desire to obtain social status or admiration (Deci & Ryan, 1985). In videogames, a sense of relatedness can occur when people develop an emotional relationship with their avatars or when friends play together (Rigby & Ryan, 2011). Satisfaction of these three needs is supposed to facilitate intrinsic motivation – a type of autonomous regulation that is associated with more beneficial outcomes than being motivated merely by rewards or punishment (Deci & Ryan, 1985).

SDT could thus provide an important perspective on the question why children would play AVGs. More specifically, it is likely that children will be inclined to play AVGs when these fulfill their needs for competence, autonomy and relatedness. The fact that two of the studies included in the present meta-analysis reported increases in self-efficacy / perceived competence as a result of the AVG intervention certainly corroborates the importance of feeling competent (Staiano et al., 2013; Wagener et al., 2012).

The importance of relatedness is underlined by the results of another included study. This study included a cooperative AVG condition and a competitive AVG condition and compared these conditions to a control group (for the present meta-analysis these two intervention conditions were pooled to calculate an average effect size) (Staiano et al., 2013). Participants in the cooperative AVG condition worked together with a second player to burn calories and hence win the game, while competitive AVG participants competed against the other player. Interestingly, the results revealed that the effect of the AVG intervention was particularly pronounced in the cooperative AVG condition, where we can assume players experienced more relatedness: Cooperation resulted in more weight loss and increased self-efficacy than competition.

Unfortunately, no research exists that systematically investigates the role of competence, autonomy and relatedness in AVG play. In fact, only two studies to our knowledge investigated the effects of different kinds of AVG play (see above) (Kim et al., 2014; Staiano et al., 2013). Future studies should look beyond the effects of AVGs on BMI and should also investigate how AVG play can satisfy basic psychological needs.

Besides from investigating psychological and motivational factors in AVG play, it could be argued that research into AVGs could benefit from a closer look at gamification theory. As mentioned in the Introduction, Deterding et al. (2011) define gamification as the use of game design elements in non-game contexts. They go on to suggest that game design elements can be conceptualized on five distinct levels. The first level consists of 'game interface design patterns', which are prototypical game elements that can be implemented quickly, like badges or leaderboards. These constitute the most concrete game design elements, with the other four levels getting more abstract. The second level consists of 'game design patterns and mechanics', which concern gameplay, like limited resources or time constraints. On the third, fourth and fifth level, interventionists not so much add game components to existing interventions, but rather think about the intervention as a game from the outset. They use accepted game-design principles (level 3) and models of game components (level 4) to design the game/intervention. Also, they organize their work using game-design specific practices and processes (level 5). According to Deterding and colleagues, game design elements on all of these five levels can be used in gamification. When surveying these possibilities, it becomes clear that AVGs constitute only one way to employ gamification in exercise programs.

At the first level of gamification, recording participants' progress and rewarding them with badges and high scores, for instance, could be one easy, low-tech and concrete way to increase engagement with exercise programs. Unfortunately, there is a dearth of research into the effects of employing different game design elements. A notable exception is a study by Zuckerman and Gal-Oz (2014), which investigated the effects of 1) feedback on progress and 2) rewards in an intervention aimed at increasing everyday moderate physical activity. Their results showed that feedback on progress significantly increased moderate physical activity, while added rewards did not have an additional effect. Further research is necessary to investigate whether sensitive feedback is indeed more powerful than rewards in obesity prevention for young people. Such research, attempting to disentangle gamification effects, would allow us to improve the effectiveness of exercise programs further.

On a higher level, game design methods and models could be used to think about the design of an obesity prevention intervention. This would constitute a more comprehensive gamification approach. It should be noted that such a comprehensive approach was absent from the studies that were included in the present meta-analysis. In these studies, existing AVGs were mostly used as a stand-alone intervention. Game-design methods or models were notably absent from these interventions. Future research should investigate whether game-design methods and models can provide an effective starting point for thinking about the design of obesity-prevention interventions (Giabbanelli & Crutzen, in press).

CONCLUSION

In sum, the results of the present study allow for cautious optimism with regards to the effectiveness of AVGs for health promotion in children. As the research on AVGs is extended, meta-analytic procedures are indispensable to obtain valid quantitative estimates of AVGs' effects. With the publication of additional empirical studies, these quantitative estimates will become more accurate, and the statistical power of moderator analyses and tests of publication bias will increase (Hedges & Pigott, 2004; Hempel et al., 2013; Sterne et al., 2011). Future studies should investigate motivational factors as potential predictors of game play. Self Determination Theory seems to provide a valid framework for doing so.

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KEY TERMS AND DEFINITIONS

Active Videogames (AVGs): “Interactive video or electronic games that feature player movement, such as would occur in ‘real-life’ exercise participation” (Bailey & McInnis, 2011).

Exercise Programs: Intervention programs designed to promote physical exercise.

Exergames: See Active Videogames (AVGs).

Fixed Effect Model: Meta-analytic approach in which effect sizes are analyzed as if they stem from a single populations of effect sizes.

Gamification: "The use of game design elements in non-game contexts" (Deterding, Dixon, Khlaled, & Nacke, 2011).

Meta-Analysis: A method of combining effect sizes from individual studies into a single composite effect size.

Random Effects Model: Meta-analytic approach in which effect sizes are analyzed as if they stem from multiple subpopulations of effect sizes.