The use of serious games and gamification within interventions for obese and overweight children and adolescents

A systematic review

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Abstract

Background: Obesity and overweight have become a common societal problem. The prevalence is rising steadily, especially among children and adolescents. This leads to considerable consequences for the physical as well as for the psychological health. Furthermore, obesity and overweight during youth often lead to obesity and overweight in adulthood. Therefore, effective interventions, especially for children and adolescents, are needed. A recently evolved field of treatment makes use of video games and game elements, called serious games and gamification. This paper aims at defining the state of the art of this new approach concerning the use of serious games and gamification within interventions for obese and overweight children and adolescents.

Method: This paper is a systematic review according to the PRISMA-P framework. It makes use of a pre-existing database consisting of 362 interventions about serious games and gamification within health care. The screening processes with item specific criteria leads to a pool of 11 interventions which are included for the data extraction. During this process the interventions are assessed according to six pre-defined criteria.

Results: Most of the interventions aim to alter a combination of physical activity and certain psychological aspects, such as intrinsic motivation. For that purpose, most interventions make use of commercially available serious exergames. None of the included studies uses gamification. All interventions, except for one, are categorised as more effective according to the present framework.

Conclusions: Serious games, educational as well as exergames, do positively influence psychological aspects such as intrinsic motivation by combining serious issues with gaming. By that, the other aspects, physical activity as well as diet and nutrition, also do improve. Therapeutic serious games can be adjusted individually to the user. That aspect could serve as an important advantage. The effectiveness of games in general is promising. But it is important to involve guidelines with reference to the frequency of usage of the intervention elements to maintain the participation of the users.

Samenvatting

Achtergrond: Overgewicht is een veel voorkomend maatschappelijk probleem. De prevalentie stijgt voortdurend, bijzonder bij kinderen en jongeren. De gevolgen zijn enorme consequenties voor de fysieke en psychische gezondheid. Bovendien heeft overgewicht onder jongeren vaak overgewicht tijdens de volwassen leeftijd als gevolg. Uit deze reden zijn effectieve interventies, bijzonder voor jongeren, heel belangrijk. Een nieuwe behandelmogelijkheid maakt gebruik van video spelen en spel elementen, genoemd serious games en gamification. Het doel van deze bachelorthese is het definiëren van de actuele stand van zaken van deze nieuwe behandelmogelijkheid. Hierbij wordt vooral gelet op het gebruik van serious games en gamification in interventies voor te zware kinderen en jongeren.

Methode: Deze bachelorthese is een systematische review volgens het PRISMA-P systeem. Er wordt een bestaande database gebruikt die 362 interventies over serious games en gamification in de gezondheidszorg includeert. Na het filteren van deze interventies volgens specifieke criteria worden 11 interventies voor de data extractie geïncludeerd. Tijdens dit proces worden deze interventies beoordeeld ten opzichte van zes tevoren vastgestelde criteria.

Resultaten: De meesten van de geïncludeerde interventies proberen een combinatie van fysieke activiteit en verschillende psychologische aspecten, zoals intrinsieke motivatie, te verbeteren. Daarvoor gebruiken de meeste interventies commercieel beschikbare serious exergames. Geen interventie maakt gebruik van gamification. Alle interventies, behalve één, worden gecategoriseerd als meer effectief volgens het toegepast schema.

Conclusies: Serious games, zowel educatie als exergames, hebben positieve invloed op psychologische aspecten, zoals intrinsieke motivatie door het combineren van serieuze dingen met games. Op deze manier verbeteren zich ook de andere aspecten, zowel fysieke activiteit als voeding. Therapeutische serious games kunnen individueel voor de gebruiker worden toegepast. Dit zou een voordeel kunnen zijn. De effectiviteit van games is veelbelovend. Maar het is belangrijk om richtlijnen voor het gebruik van de interventies op te stellen om de participatie van de gebruiker te behouden.

1. Introduction

Overweight and obesity nowadays seem to be a common societal phenomenon. In 2014, the World Health Organization defined 1, 9 billion of adults as overweight, of which 600 million were obese. This corresponds to 39%, respectively 13% of the global population. Currently, 42 million children younger than 5 years of age are regarded as overweight or obese (World Health Organization, 2015). This widespread overweight and obesity among children and adolescents (paediatric overweight and obesity) is seen as an important cause for overweight and obesity in adulthood (Jebb & Lambert, 2000). According to Maffeis (2000), in 30 – 60% of all cases, overweight in childhood continues in adulthood. Often, the intense usage of media is seen as an important cause for overweight and obesity, especially among children and adolescents. Frequently, one reads headlines like this one, found in the Daily Mail: "Computer and TV lead to child obesity" (Fletcher, n.d.). The extensively high prevalence of paediatric overweight and obesity not only shows the importance of prevention, but also of effective intervention. Besides, children have less control about their own behaviour than adults do. Much of their behaviour is applied externally by adults, especially by their parents (Zwiauer, 2000). Therefore, society has a special responsibility for them. Effectively helping and protecting them is mandatory. But, if children are actually using digital media that much, this could also serve as a chance for protecting them of negative consequences. Perhaps, modern media could actually be used to reduce paediatric overweight and obesity. But before this question will be addressed in detail, a broad overview of this issue will be provided.

1.1 Paediatric Overweight and Obesity

According to the World Health Organization (2015), overweight is generally defined as a BMI greater than or equal to 25. Obesity is called a BMI greater than or equal to 30. Basically, the body mass index or BMI is an official measure of body weight which is equal to weight (kg)/length² (m) (Morrison & Bennet, 2013). For children and adolescents up to 19 years of age exist specific interpretations which depend on mean and standard deviation within age groups, for girls and boys separately (World Health Organization, 2015).

Obesity and overweight are referred to as the "leading cause of preventable death" (Zwiauer, 2000). Since 1980 until 2013 the worldwide prevalence rose by 47.1% for children including adolescents up to 19 years of age (Ng et al., 2014). Even a significant part of infants is overweight. For example in the Netherlands, between 2002 and 2006, ca. 8% of the 2-years-old suffered from overweight. For the 4-years-old this percentage amounted even to ca. 12% (Cattaneo et al., 2009).

Obesity and overweight among children and adolescents have a broad range of both, short-term and also longer-term consequences. According to Jebb and Lambert (2000) it is related to physical as well as psychosocial consequences. Furthermore, it entails an increased likelihood of adult obesity. According to Maffeis (2000), this applies to 30-60% of the cases. Overweight not only increases mortality, it also causes psychological problems, like social isolation and diminished sense of self-esteem (Morrison & Bennett, 2013). Another important aspect to mention is that overweight and obesity lead to a considerable burden for the health systems (Zwiauer, 2000) because of increased medical costs and intensive personnel placement. All these different consequences of paediatric obesity and overweight and the extensively high prevalence show the importance of prevention and intervention.

There are different causes for paediatric overweight and obesity. Leman et al. (2012) emphasize that there is genetic heritance. According to them, this can be proven by adoptive studies. Furthermore, those genetic influences would already be present in little infants by directly influencing their taste in terms of preference for sweet tastes. It seems like the BMI inheritance accounts for 25-40% of the BMI variability (Maffeis, 2000). Maffeis (2000) stresses that this inheritance does not act as a direct cause for obesity. Rather, it leads to an increased sensitivity to fat gain in risky environments. Morrison & Bennett (2013) do not deny the presence of genetic influences, but they argue that the recent rise in prevalence is caused by environmental influences which they call an "obesogene environment". According to them, the main reason for overweight and obesity among children and adolescents is that their energy intake is much higher than the energy needed. Environmental influences, especially parents are particularly important causes. The parents' feeding practices during infancy strongly influence the child's own food choices (Maffeis, 2000). Children's and adolescents' behaviour control is applied externally by parents or other adults in charge of them (Zwiauer, 2000). Hence the caregivers, especially the parents, have a crucial responsibility for paediatric overweight. Other negative influences on child's weight are low physical activity, poor energy balance and preference for fatty diet (Maffeis, 2000).

Mostly, interventions for obese and overweight children and adolescents refer to dietary habits (i.e. understanding what is healthy food and what makes fat) as well as physical activity (i.e. physical exercise adapted to the individual) (Jebb & Lambert, 2000; Zwiauer, 2000). For achieving behavioural change and weight loss two critical factors to consider are the role of personal motivation and family commitment (Jebb & Lambert, 2000). Basically, interventions for obese and overweight children and adolescents have three components. The first one is the behavioural approach. In order to achieve a relevant change in behaviour, the

intervention starts with monitoring the current situation. When working with little children, it is mandatory to involve the parents during this process. After analysing the current situation, the children have to set goals. These have to be "realistic and achievable within a time frame […] easily comprehensible and not cause frustration" (Zwiauer, 2000). For supporting the achievement of these goals, it is important to positively motivate and reward the children. The second component of interventions for paediatric overweight and obesity has reference to diet and nutrition. It is based on the idea that obese children consume more energy than they need. That is why, an important part of an intervention for children is teaching them about healthy eating, dietary principles and calories. The third component of those interventions acts on the patient's physical activity. This is implemented by a combination of lifestyle exercises, like walking stairs instead of taking the lift, as well as planned exercise, like participating in sport lessons (Zwiauer, 2000). According to Staniford, Breckon and Copeland (2012), holistic interventions that include all of the three components are the best available option for treatment. Moreover, they stress the importance of family involvement. But there are also limitations about classical treatment strategies. The main problem is the high inconsistency around study design, quality and outcome measurements (Staniford et al., 2012). This limits the comparability of effectiveness.

1.2 Serious Games and Gamification

These components can be implemented in different ways. One innovative option is the use of computer or video games in different areas of health care. The already high usage of such games among children and adolescents could also have influence on the effectiveness within interventions. Many studies found that motivation is a crucial factor for the success of interventions for obese and overweight children and adolescents (Yano, Ebesutani, Lu & Choy, 2009). It has significant effects on progress in physical exercise activities and healthier nutritional choices (Ward-Begnoche, Pasold, McNeill, Peck, Razzaq, McCrea Fry & Young, 2009). Intrinsic motivation prevents the patients from feeling forced to change their behaviour. If they feel free and intrinsically motivated, not only the success of the intervention will be more likely, but also the positive long-term effects will increase (McWorther, Wallmann & Alpert, 2003). The high usage of games among children and adolescents could serve as a means for motivation during these interventions because in everyday life games are used for purposes of entertainment. Common interventions do not have this advantage because motivation has to be created more effortful. That is why, this new approach seems to be promising.

When using games in health-care, one basically differentiates between two main categories. The first one is *gamification*. It is defined as "the use of game design elements in non-game contexts" (Deterding, Khaled, Nacke & Dixon, 2011). It is based on "established game-based approaches" (Wood & Reiners, 2015) with reference to behavioural economics and psychology. This means that game elements are specifically used to positively influence people, based on ideas from sciences about human nature. The second category is called *serious games*. These are "complete games [used] for non-entertainment purposes" (Deterding et al., 2011). They can be separated into two groups. The first one includes "commercially available games modified or used with limited functionality to meet therapeutic needs" (Szczesna, Grudzinski, Mikuszewski, & Debowski, 2011). These can be devices like the Nintendo Wii which is used for therapeutic purposes, instead than just for entertainment. The second group are serious games which were explicitly developed for the use in therapy. One specific type of serious games are exergames. These games combine physical activities with technology-based game-play (Witherspoon, 2013). The probably best known example of an exergame is the Nintendo Wii. The basic idea of both, serious games and gamification, is that games could be used for more serious purposes than only for entertainment. Basically, games are thought to motivate patients, especially children and adolescents because computers are an accepted part of children and teenage culture, as was already stated above. Furthermore, games are thought to support self-reflection and behaviour change because of exactly these motivating influences (Szczesna et al., 2011).

1.3 Aim of the Study

In summary, there seem to be many implementations of serious games and gamification for the use within interventions for obese and overweight children and adolescents. That makes it important to evaluate the existing literature. An analysis of the applications and successes of this approach could contribute to an improvement of future interventions. For that purpose it is necessary to answer several questions. To begin with, it has to be investigated, which aspects are tried to be altered by the interventions. Possible aspects to be altered during an intervention could be behavioural change referring to eating behaviour or physical activity or educational aspects like knowledge about food. Secondly, it would be important to examine, what kinds of games or game-elements are used within interventions for paediatric overweight and obesity. This knowledge could serve as a base for further improvements of interventions and new developments. Finally, it has to be examined, how effective the use of

games and gamification within interventions for obese and overweight children and adolescents is.

That is why, one main research question and three appropriate sub-questions were formulated. These will be addressed in this paper by means of a systematic review of an existing database including interventions about the usage of serious games and gamification within health care.

What is the state of the art of interventions for obese and overweight children and adolescents which make use of serious games and gamification?

1. *Which behaviours are tried to be altered through the intervention?*
2. *What kinds of games or game-elements are used within the intervention?*
3. *How effective is the intervention?*

2. Method

2.1 Data Sources and Search Strategy

This systematic review will be based on the PRISMA-P framework (Moher, Shamsser, Clarke, Ghersi, Liberati, Petticrew, Shekelle, Stewart & PRISMA-P Group, 2015) which consists of a four step approach. This paper makes use of an existing data base. The first step of identification was already carried out by two researchers of the University of Twente (Ern, 2014; Knüwer, 2014). This resulted in a data base consisting of 362 articles which fulfil the following criteria: They are about an intervention, aimed at people with health problems, intend to promote health, contain games or game-elements, are retrievable online, are available in English, Dutch or German, contain information about the game-elements and are no reviews.

The aim of the present screening process is to find literature about the use of serious games and gamification within interventions for obese and overweight children and adolescents. For this purpose two additional inclusion criteria were formulated: The studies have to thematise obesity and/ or overweight (1) and have to be explicitly designed for children and/ or adolescents (2).

As already stated before, the first step of identification resulted in a data base consisting of 362 articles. The following step, according to the PRISMA-P framework, is called screening. During the screening process the inclusion criteria were successively applied. First, the titles and abstracts of the 362 articles were screened with the keywords obese and overweight. After that, 19 articles remained. Subsequently, these were screened with the keywords child and adolescent. This resulted in a data base consisting of 14 articles. These were included in the full-text screening. Two articles were excluded, because they evaluated interventions which were already included. In these cases, only the original paper was included. Two other papers will be used combined because the first describes the intervention and the second gives the appropriate results. Finally, in the last step of the framework, 11 interventions, described in 12 articles, were included for the data extraction. This process is depicted graphically in Figure 1.

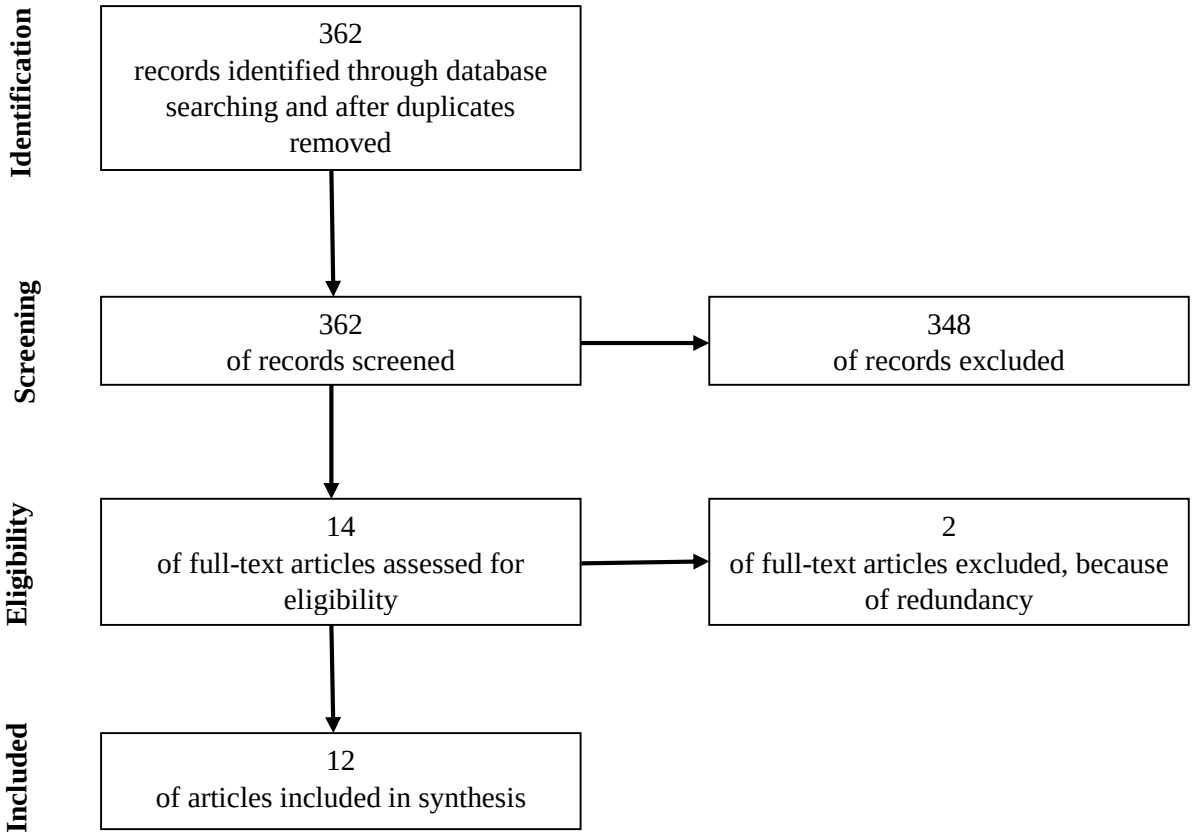

Figure 1. Search Strategy according to PRISMA-P

2.2 Criteria for Data Extraction

For the purpose of finding answers to the research question and sub-questions of this paper, six criteria were formulated, which will be defined in detail in the next paragraphs. These will serve as a means for systematically extracting the relevant data from the remaining articles and also for purposes of comparison. The first three criteria are meant to give an overview and broad understanding of the given intervention. The latter ones have reference to the sub-questions of this paper.

2.2.1 Method of the Intervention

Within this category, an overview of the studies will be provided. This includes a broad range of aspects, such as the intended procedure and time frame, as well as other relevant elements, like the design of the study (e.g. control group or single group design). By that, one gets an

idea of the main characteristics of the given intervention. These information will serve as a base for understanding of the further data extraction.

2.2.2 Name of the Intervention

The name of the intervention will be reported here. If there is no specific name for the given intervention, the name of the technology which is used (e.g. Nintendo Wii) will be announced. This category is introduced for reasons of clarity and comprehensibility.

2.2.3 Participants and Setting

The most relevant characteristics of the participants and the setting in which the intervention takes place will be described within this category. Such relevant characteristics can be aspects, such as age of the participants, BMI, ethnicity or gender. The settings can be located for instance at home or in a clinical environment. All known information about these features will be mentioned here. This category will provide a deeper understanding of the given interventions.

2.2.4 Behaviour Aimed to Be Altered

Commonly, within interventions for obese and overweight patients, different aspects of behaviour are tried to be altered. Based on the theory of Zwiauer (2000), three categories are formulated: (1) diet and nutrition, (2) physical activity and (3) psychological aspects (e.g. intrinsic motivation, self-efficacy). This will make the data more comparable. Of course, also other behaviours can be involved. If the behaviours aimed to be altered by the intervention do not fit into the given categories, they will be mentioned without being categorised. This category refers to the first sub-question of this paper.

2.2.5 Technology Used

Since all interventions investigated in this paper are making use of serious games or gamification, the precise game or game-element which is used will be reported within this category. For that purpose, this paper will make use of the exact information from the text. If no specific games are named in the given article, the technology which is used will be mentioned (e.g. Nintendo Wii). Furthermore, this paper will differentiate between exergames, as defined in the introduction and educational games which teach information playfully. This category gives information concerning the second sub-question of this review.

2.2.6 Effectiveness

Information about the effectiveness of the interventions will be derived from the information given in the articles. This means that the relevant data from the results will be analysed. These

are the changes in the measured variables, like weight, BMI or other health aspects. Also, relevant differences between an eventual control and target group will be assessed. Moreover, if appropriate, the recommendations for further research will be taken under investigation to clarify the limitations of the interventions.

For the purpose of making these information comparable, this paper makes use of a framework introduced by Morrison, Yardley, Powell and Michie (2012). This given framework offers a possibility to classify diverse information into one scheme with three categories: more effective, less effective and ineffective (Table 1). If the information from the articles do not fit into that scheme, the existing information will be merely mentioned without being categorised. This category gives answers to the third sub-question of this paper.

Table1. *Criteria for Defining Intervention Effectiveness According to Morrison et al. (2012)*

INTERVENTION CODE	CRITERIA
MORE EFFECTIVE	• The intervention led to improvement on the majority of outcome measures. • The intervention was at least as effective as comparison groups. • The intervention was more effective than waiting list or no intervention control groups.
LESS EFFECTIVE	• The intervention led to improvement on a minority of outcome measures. • The intervention was not necessarily as effective as comparison groups. • The intervention was more effective than waiting list or no intervention control groups.
INEFFECTIVE	• The intervention did not lead to improvement on any of the outcome measures. • The intervention was no more effective than waiting list or no intervention control groups.

3. Results

Before the data extraction will take place, the studies which are involved will be presented in the following table (Table 2). For reasons of clarity and comprehensibility, every intervention will be provided with a code. The two interventions which are used in combination, as explained in the previous section, have the same code.

When looking at the years of publication, it gets obvious that all interventions are very current. They are all published within the time frame from 2008 to 2013, whereby most articles were published in 2012. This shows that use of serious games and gamification within health care, specifically within intervention for obese and overweight children and adolescents, is a contemporary issue.

Table 2. *Code Scheme for the Literature Included for Data Extraction*

CODE	AUTHORS	YEAR	TITLE
I1	Adamo, K. B., Rutherford, J. A. & Goldfield, G. S.	2010	Effects of interactive video game cycling on overweight and obese adolescent health.
I2	Christison, A. & Khan, H. A.	2012	Exergaming for health: A community-based paediatric weight management program using active video gaming.
I3	Delamater, A. M., Pulgaron, E. R., Rarback, S., Hernandez, J., Carillo, A., Christiansen, S. & Severson, H. H.	2013	Web-based family intervention for overweight children: A pilot study.
I4	Guixeres, J., Saiz, J., Alcañiz, M., Cebolla, A., Escobar, P., Baños, R., Botella, C., Lison, J. F., Alvarez, J., Cantero, L. & Lurbe, E.	2013	Effects of virtual reality during exercise in children.
I5	Maddison, R., Foley, L., Mhurchu, C. N., Jull, A., Jiang, Y., Prapavessis, H., Rodgers, A., Hoorn, S. V., Hohepa, M. & Schaaf, D.	2009	Feasibility, design and conduct of a pragmatic randomized controlled trial to reduce overweight and obesity in children: The electronic games to aid motivation to exercise (eGame) study.
I5	Maddison, R., Foley, L., Mhurchu, C. N., Jull, A., Jiang, Y., Prapavessis, H., Hohepa, M & Rodgers, A.	2011	Effects of active video games on body composition: a randomized controlled trial.
I6	Munguba, M. C., Valdés, M. T. M. & da Silva, C. A. B.	2008	The application of an occupational therapy nutrition education programme for children who are obese.
I7	Murphy, E. C. S., Carson, L., Neal, W., Baylis, C., Donley, D. & Yeater, R.	2009	Effects of an exercise intervention using Dance Dance Revolution on endothelial function and other risk

			factors in overweight children.
I8	Radon, K., Furbeck, B., Thomas, S., Siegfried, W., Nowak, D. & von Kries, R.	2011	Feasibility of activity-promoting video games among obese adolescents and young adults in a clinical setting.
I9	Staiano, A. E., Abraham, A. A. & Calvert, S. L.	2012	Motivating effects of cooperative exergame play for overweight and obese adolescents.
I10	Staiano, A. E., Abraham, A. A. & Clavert, S. L.	2012	Competitive versus cooperative exergame play for African American adolescents' executive function skills: Short-term effects in a long-term training intervention.
I11	Wagener, T. L., Fedele, D. A., Mignogna, M. R., Hester, C. N. & Gillaspy, S. R.	2012	Psychological effects of dance-based group exergaming in obese adolescents.

3.1 Method of the Intervention

In the following part, the methods of the interventions will be described. This will provide an overview and a basic understanding of the given interventions. The descriptions show the whole structure and chronology of the intervention. This includes the study design and all measures which are taken. The whole description of the methods of the intervention is described in Table 3 below.

The studies make use of very diverse designs. I1, I5, I7, I9 and I11 make use of a two group design, whereby I5, I7 and I11 use a traditional treatment and control group design. I1 compares two different exercise groups (exergame vs. exercise to music) and I9 compares competitive and cooperative exergaming. I10 also compares competitive and cooperative exergaming, but also involves a third control group. The remaining interventions (I2, I3, I4, I6 and I8) make use of a single group design. I8 includes one group which tests one game. I4 and I6, by contrast, make use of one group which tests two treatments. In I6 the participants test two kinds of games and in I4 they test an exergame and traditional exercise. Also the duration of the interventions have a broad range from one day (I4) to 24 weeks (I5). Most intervention take place during a time period of 10 weeks (I1, I2, I10, and I11).

Table 3. *Method of the Intervention.*

CODE	METHOD OF INTERVENTION
I1	The purpose of this study is to compare the effects of using a GameBike versus doing classical cycling to music on exercise adherence, duration and intensity (measured during exercise), submaximal aerobic fitness, metabolic parameters and body composition (measured at baseline and at the end). The study uses two groups. The experimental group makes use of a GameBike with race-based video games. The comparison group exercises on the GameBike turned off while listening to music of their own choice. Both groups can freely chose the intensity and duration of exercise. The sessions take place two times per week for 60 minutes during 10 weeks.
I2	The purpose of this study is to evaluate a community-based weight management programme involving families. The intervention consists of 10 weekly sessions involving five hours of nutrition education, five hours of psychosocial and behavioural education and 10 hours of physical exercise using exergames. Additionally, the participants are able to do three additional hours of exergaming per week. The study measures the effects on weight, BMI, psychological and behavioural measurements. All measurements are taken at the baseline and at the end of the intervention.
I3	The purpose of this study is to test a web-based family intervention programme for overweight children including two educational games. The families use the website for four weeks and are encouraged to use it at least several times per week. The study investigates the effects of the intervention on weight, BMI, psychological variables and behavioural variables.
I4	The purpose of this study is to test the Virtual Reality Exercise Platform (VREP), developed by the authors. The study consists of three parts. Firstly, initial measurements are taken. Secondly, the participants do 15 minutes of traditional exercise on a treadmill. Then, they have 20 minutes of rest. Afterwards, the participants do 15 minutes of exercise on a treadmill with the VREP. During exercise, the participants are wearing a shirt measuring their physiological responses. Thirdly, the respondents fill in an Acceptability Scale referring to the use of the VREP.
I5	The purpose of this study is to examine the effects of active video games on weight, body composition, physical activity and fitness. The study makes use of a two group design including a wait-list condition. The intervention group gets an exergame package with

	which they are encouraged to meet certain physical activity recommendations during 6 months. Before, the free-living physical activity is measured. At the baseline, after 12 and after 24 weeks different variables are assessed: height, weight, waist circumference, bioelectrical impedance analyses, field test of physical fitness, self-reported physical activity, self-reported video game use, self-reported snack food consumption and psychological variables.
I6	The purpose of this study is to evaluate a nutritional education programme for obese children using two games and to compare them. The intervention takes places during four months. The first game is a video game which teaches children about healthy nutrition individually. The second game is a board game which does the same based on competition. The study investigates the effects on learning, fantasy during that process, and the need of help during learning. These effects are investigated by semi-structured interviews, observation and a focus-group technique at the end of the intervention.
I7	The purpose of this study is to determine the effectiveness of Dance Dance Revolution (DDR) on health risk factors in overweight children. The study uses an exercise and a control group. The participants are encouraged to use the DDR five days per week. The duration of the sessions should increase each week. The participants have to record their daily physical activity time and daily non-active screen-time. Moreover, they wear a pedometer. The measurements are taken at the baseline and at week 12. These include: Assessment of aerobic exercise capacity, anthropometric measurements, vascular testing and assessment of blood chemistry.
I8	The purpose of this study is to test if activity promoting video games (apvg) are a suitable treatment to enhance physical activity in obese adolescents in a clinical setting. The intervention is carried out over three months and makes use of three exergames. The participants can use the tools individually or in groups every day in scheduled times. The utilization habits are documented during the sessions. Furthermore, the frequency of participation is counted, sociodemographic data are taken from the patient files and questionnaires about knowledge of apvg and prior media consumption are taken. Two times per week and during the intervention sessions the heart rate is measured.
I9	The purpose of this study is to compare the effects of cooperative and competitive exergame play in obese and overweight youth. This study makes use of a two group design, including a competitive and a cooperative group. The intervention takes place over 20 weeks. Both groups do a preassigned exergame routine with increasing intensity and duration. In both groups, every participant gets a random partner to play with. Each day the top three players per condition are announced. During the sessions, the participants are

	wearing an accelerometer. The other measurement are taken at the end of the intervention: intrinsic motivation, psychological attractiveness of game design and a structured interview.
I10	The purpose of this study is to investigate the short-term effects of Wii Sports exergaming on obese adolescents' executive function skills in different conditions. The study uses three groups: cooperative, competitive and no-play. The intervention takes 10 weeks with five sessions of 30 minutes exergaming with a peer per week. During exercise the duration of play and caloric expenditure is measured. Moreover, the participants' executive function skills are tested at the baseline and at the end of the intervention.
I11	The purpose of this study is to investigate the impact of a dance-based exergame on obese adolescents' BMI, psychological adjustment and perceived competence to exercise. The study uses an exergame group and a wait-list group. The exergame sessions take place three times per week for 10 weeks with increasing duration. The difficulty of the game is adjusted to the heart rate automatically. Both groups are asked not to modify their dietary habits. Measurements are taken at the baseline and at the end of the intervention: BMI, height, weight, self-reported competency regarding maintaining regular exercise and adolescent and maternal report of adolescent psychological adjustment.

In Table 4, the results of the remaining categories of the data extraction will be presented. First, they will be described for each category separately.

3.2 Name of the Intervention

Only four of the 11 intervention which are involved have a specific name (I2, I3, I4 and I5). The other are simply named by the technology of which they make use during the intervention.

3.3 Participants and Setting

The age of the participants ranges from 8 to 28 years of age. Five studies only include adolescents (I1, I8, I9, I10 and I11) and three only include children (I3, I6 and I7). I4 and I5 include participants which fall between the categories of children and adolescents and I2 includes both because of a broad range of age.

In five of the studies, the participants have to be at least overweight (BMI above 85^{th} percentile; I2, I3, I5, I7 and I9). In I1 the participants have to be at least overweight, but with additional constraints. I4 has an obese and a non-obese group. In I11 and I8, the participants have to be obese (BMI above 95^{th} percentile), whereby in I8, they also have to be clinical patients. In I6 and I10, there are no specific weight-related inclusion criteria. Furthermore, I2 and I3 involve the whole family in their intervention.

Seven of the interventions take place in a fixed external location, such as a village hall (I1, I2, I4, I6, I9, I10 and I11). Three are located at home of the participants (I3, I5 and I7). One intervention is situated in a clinical setting (I8).

3.4 Behaviour Aimed to Be Altered

Most of the interventions aim to alter a combination of physical activity and psychological aspects (I4, I5, I9, I10 and I11). Three intend to alter only physical activity (I1, I7 and I8). Two interventions try to change all, diet and nutrition, physical activity as well as psychological aspects (I2 and I3). The remaining intervention (I6) only tries to change the diet and nutrition.

While the categories diet and nutrition as well as physical activity are quite distinct, the third category is more diverse. Three of the interventions try to change the intrinsic motivation to do physical exercise (I3, I5 and I9). Two include improving the enjoyment of physical activity (I4 and I5). Two others try to alter the perceived competence to do physical activity (I5 and I11). Moreover, I2 involves psychosocial and behavioural education, I11 wants to improve the psychological adjustment and I10 aims at improving the executive

functioning of the participants. All these aspects are summarised within the category psychological aspects.

3.5 Technology Used

The intervention make use of a broad range of games. Many interventions even use several games in their programmes. Only three interventions make use of a programme which is not commercially available (I3, I4 and I6). All other interventions make use of commercially available games which are used as serious games for therapeutic purposes. Within I1, I4, I5, I6, I7, I8, I9, I10 and I11 the games are used as single means of intervention. In I2 and I3, the games are elements of a broader intervention. Nine of the interventions make use of exergames (I1, I2, I4, I5, I7, I8, I9, I10 and I11), while the remaining two use educational games (I3 and I6).

3.6 Effectiveness

According to the framework introduced by Morrison et al. (2012), which was represented in Table 1, 10 of the 11 interventions have to be categorised as more effective.

Only I8 is categorised as ineffective because there were no improvements in any of the outcome measures. In this case, the reason for these results was that no participant finished the intervention programme completely. The authors note that the intervention took place on a voluntary base without a predetermined schedule.

Table 4. *Results of the Data Extraction.*

CODE	NAME	PARTICIPANTS AND SETTING	BEHAVIOUR AIMED TO BE ALTERED	TECHNOLOGY USED	GAME TYPE	EFFECTIVENESS
I1	GameBike	Adolescents between 12-17 years of age with BMI above 95th percentile or above 85th percentile with obesity-related diseases; Fixed external location	Physical activity	GameBike; Play Station race-based video games	Exergame	More effective
I2	Exergaming for Health	Children and adolescents between 8-16 of age with BMI above 85th percentile; Fixed external location	Diet and nutrition; Physical activity; Psychological aspects	Dance Dance Revolution (DDR); Exerbike XG; Wii tennis and boxing; Makoto Interactive Arena; Lightspace Play Floor; Cybex Trazer; Treadwall; Xavix system for boxing and tennis	Exergame	More effective
I3	Families Interacting Together for Health (FIT-4-Health)	Children between 8-12 years of age with BMI above 85th percentile; Home setting (own computer)	Diet and nutrition; Physical activity; Psychological aspects	FIT-4-Health website including two interactive games for teaching knowledge and skills about healthy nutrition and physical activity	Educational game	More effective
I4	Virtual Reality Exercise	Children between 10-14 years of age including an obese and a non-obese	Physical activity; Psychological aspects	Virtual Reality Exercise Platform (VREP)	Exergame	More effective

	Platform (VREP)	group; Fixed external location				
I5	Electronic Games to Aid Motivation to Exercise (eGame)	Children between 10-14 years of age who are overweight; Home setting (digital upgrade at home)	Physical activity; Psychological aspects	Play Station; Eye Toy with camera, dance mat and several active video games	Exergame	More effective (no results for psychological aspects available)
I6	Video and Board Game	Children between 8-10 years of age; Fixed external location	Diet and nutrition	Video (individually) game and Board (competitive) game which are based on the food pyramid	Educational game	More effective
I7	DDR	Children between 7-12 years of age with BMI above 85th percentile; Home setting	Physical activity	Play Station with DDR	Exergame	More effective
I8	Play Station 2 with Eye Toy	Adolescents between 13-28 years of age who are obese and inpatient; Clinical setting	Physical activity	Play Station with Eye Toy and Play 3, Kinetic and Play Sports	Exergame	Ineffective
I9	Nintendo Wii	Low-income African American adolescents between 15-19 years of age who are overweight or obese; Fixed external location	Physical activity; Psychological aspects	Wii	Exergame	More effective

I10	Nintendo Wii	African American adolescents between 15-19 years of age who are mostly obese; Fixed external location	Physical activity; Psychological aspects	Wii EA Sports	Exergame	More effective
I11	Dance Dance Revolution	Adolescents with a BMI above 95th percentile; Fixed external location	Physical activity; Psychological aspects	DDR	Exergame	More effective

4. Discussion

The purpose of this systematic review was to get an overview of the state of the art of interventions for obese and overweight children and adolescents which make use of serious games and gamification. For that purpose, three research sub-questions were formulated. During the data extraction and analysis of the 11 interventions which were included, much information concerning these questions was found. First, it was found that most of the included interventions try to alter a combination of physical activity and psychological aspects. Second, the data extraction found that most interventions make use of commercially available serious exergames. No intervention involved gamification. Third, the results indicate that the use of serious games within interventions for obese and overweight children and adolescents is a promising and effective approach, since most included interventions are categorised as more effective. Although this paper provides much information about the state of research of this topic, there are also some limitations about this review. Moreover, the insights of this paper lead to new questions which can serve as a base for further research about this innovative and promising approach. All these aspects, which were mentioned within this paragraph, will be explained and discussed in detail in the following sections.

4.1 General Evaluation of the Studies

Basically, all of the studies which were involved are well described and accomplished. But there are some annotations to make.

One important aspect is that most studies do not involve whole interventions. Rather, they have the design of a pilot study which are testing the effects of exergames on obese and overweight youth. That means that many studies consist of several pre- and after-measurements. Between these measurements an exergame is the only means of intervention. That is why, these studies do not seem to be completely elaborated interventions, but rather pilot studies of a new therapeutic approach. One disadvantage of this design is that the precise working mechanisms of the exergames, especially with reference to psychological aspects, are broadly unknown.

Another limitation about the involved studies is that they all measure short- or medium-term effects. But it would be important to investigate the long-term effects. It should be tested if the effects of the interventions continue during daily routine without direct intervention. This could give insight in the actual effectiveness of this kind of intervention.

These general annotations about the involved interventions will serve as a base for the understanding of the next sections of this discussion.

4.2 Behaviour Aimed to Be Altered

This study used three categories for comparing the behaviours aimed to be altered by the interventions. These three categories, diet and nutrition, physical activity and psychological aspects, were based on the theory of Zwiauer (2000) about interventions for obese and overweight youth.

Only one intervention aims at improving diet and nutrition. This, with use of educational games as single means of intervention.

Since most of the interventions make use of exergames, most of them at least involve supporting physical activity. This is the case for all interventions, except for one. But only three interventions chose for physical activity as the only behaviour which is aimed to be altered. Most interventions additionally try to improve some psychological aspects, such as intrinsic motivation. Another important finding is that these interventions use an exergame as only means of intervention. Since exergames are designed to do physical exercise in a playful manner, it is not surprising that they are used to improve physical activity within these interventions. What is more interesting is that they are also applied for improving psychological aspects, like intrinsic motivation, enjoyment of physical activity and perceived competence of doing physical exercise. When looking at the results, it gets clear that exergames actually do positively influence these psychological factors. This finding is consistent with the idea that by combining exercise with gaming, motivational aspects are increasing (Szczesna et al., 2011) and interventions are more likely to be successful (Yano et al., 2009). This could serve as an advantage compared to classical interventions.

Only two interventions involve all of the three categories of behaviour aimed to be altered. Furthermore, both holistic interventions involve the whole family. These two interventions most conform to the structure of classical interventions for obese and overweight youth (Zwiauer, 2000; Staniford et al., 2012). Moreover, these kind of interventions are thought of as most effective (Staniford et al., 2012). Therefore, they will be discussed more detailed. I2 has a very clear structure. The category diet and nutrition is tried to be improved by nutritional education. Psychological aspects are aimed to be altered by psychosocial and behavioural education. Both educational programmes involve children and parents. Physical activity is tried to be supported by exergame sessions. Here, the parents can participate on voluntary base. In this case, exergames are used as substitute for traditional exercise. The study indicates that exergaming is used to make physical exercise more fun. In other words, to motivate the participants. I3, by contrast, has a less clear structure because it is

an encompassing intervention programme based on a website including many different tools, especially two interactive educational games. One is about dietary habits and the other about physical activity. Again, it is indicated that games make serious issues, in this case learning, more easily because they are motivating.

The main finding concerning the first sub-question is that all of the three categories can be successfully altered by the use of serious games. Especially, the combination of physical activity and psychological aspects is chosen very often. The main similarity of all involved interventions is that they make use of games for the purpose of motivating their participants. By playing a game, serious issues like learning or exercising, do not seem imposed anymore. People feel intrinsically motivated to do their task. By that, the effectiveness of interventions is increasing.

4.3 Technology Used

Within this category, this paper differentiates between (1) serious games and gamification and (2) exergames and educational games.

The first thing to mention is that none of the eleven interventions which were involved makes use of gamification. All intervention use serious games. As already stated before one additionally differentiates between commercially available serious games, like the Wii, and serious games which were developed only for therapeutic usage (Szczesna et al., 2011). Eight of the interventions make use of commercially available serious games. Most of them are based on the Sony Play Station or on the Nintendo Wii. This corresponds to the idea that serious games are thought to motivate children and adolescents because they belong to their lives anyway (Szczesna et al., 2011). All of these commercially available games are categorised as exergames. They are based on the idea of combining physical exercise with gaming. Most of them are used as only means of intervention. Commercially exergames, such as the Wii, are quite modern. That could be the reason why the use in therapy is tested in so many of the involved studies. Only three interventions are therapeutic serious games which are not commercially available. Two of them make use of educational games. They aim at teaching serious issues, in this case information about diet and nutrition and physical exercise, in an interactive and playful manner. This is thought to make learning easier and more successful by intrinsic motivation (McWorther et al., 2003). The third one (I4), by contrast, uses a therapeutic exergame which combines traditional exercise on a treadmill with a virtual reality platform. This intervention is the only one which makes use of an exergame especially developed for the use within therapy. These are more individualised. This aspect is thought of

as an important factor for the success of interventions (Zwiauer, 2000). That is why, it will be described in more detail. It is based on a race game in a three-dimensional graphical environment. Moreover, it involves a Smart Shirt (TIAS) which records the physiological responses of the participants. According to the authors, this serious game differs from commercially available games in five ways. First, a psychologist is able to send individual messages to the screen to motivate the participant. Second, different aspects of the game can be configured, i.e. number of virtual opponents during the race or viewpoints. Third, the TIAS provides the researchers with real time measurements of the participants' physical reactions during exercise. Moreover, during the sessions, cognitive tasks, like remembering hidden objects, can be added to the game. Finally, the data from the TIAS can be integrated during the sessions. Basically, this exergame works on the same ideas as the commercially available ones. They all aim at motivating the users to do physical exercise by means of play. The main difference to those commercially available games is that the therapeutic game can be modified depending on the individual. According to Zwiauer (2000) this could serve as an advantage during therapy because it is important to take individual aspects into account. This could improve the success and effectiveness of such interventions.

The main finding concerning the technologies which are used during the interventions is that most of them make use of commercially available serious exergames. No intervention includes gamification. Another important aspect to mention is that these commercially available exergames could be modified for the use within therapy by making them more individual, as it was the case in I4. This could serve as an advantage compared to standard commercially available exergames.

4.4 Effectiveness

The interventions which were involved in the data extraction are very diverse with reference to their measurements. That is why, for the purpose of comparability, the results of the studies were categorised according to the scheme of Morrison et al. (2012).

It was found that all interventions, except for I8, are categorised as more effective. That means that the interventions lead to improvement on the majority of outcome measures, were at least as effective as comparison groups and were more effective than waiting list or no intervention groups. Only I8 is categorised as ineffective. The reason for that is that none of the participants completed the whole intervention. Most of them participated only until week 2 of the 12 weeks. There are some differences between I8 and the other more successful interventions. I8 is the only intervention which took place in a clinical setting. Moreover, it

was carried out on a more voluntary base than the others. There were no fixed sessions, but only a time schedule when the participants could go to a room and play how and how long they wanted to. There were no specific guidelines at all. The main reason for not participating was loss of interest.

The main finding concerning the question of effectiveness of this kind of intervention is that the use of serious games within interventions is a promising approach. But it seems like some guidelines for regular usage are mandatory. Another aspect to mention is that the diversity of the studies makes the comparability of their effectiveness problematic. That is why, no general conclusions can be drawn.

4.5 Limitations

Even if the present study succeeded to find a lot of information about the relevant issue there are also some limitations which have to be mentioned.

The most important limitation is that this study only involved interventions which made use of serious games. No information about the use of gamification within this context could be found. Furthermore, most of the serious games are commercially available exergames which were tested by pilot study designs and not within elaborated intervention programmes. So, further research about gamification and serious games within elaborated intervention programmes is needed.

Another important constraint is that the categories of effectiveness according to Morrison et al. (2012) are very broad. So, even if nearly all interventions are categorised as more effective it does not mean that they are perfectly working. For investigating this, the results would have to be examined more deeply. Therefore, another framework for comparing the effectiveness of interventions should be used. The problem which remains is that the involved interventions use very different measurements. So, the comparability still is problematic. It should be more effective to only compare interventions with similar outcome measurements. Moreover, the interventions should be equally elaborated because it is problematic to compare pilot studies to whole intervention programmes.

Moreover, this systematic review only includes very few therapeutic serious games. So, there is not much information about the working mechanisms and adequate development of these games.

The interventions only test short- and medium-term effects. There are no information about long-term effects and the sustainability of the results. It cannot be said if the positive results remain during daily routine of the participants. It is important to provide control

measurements also after completion of the intervention.

These limitations make clear that this review can only serve as a means for providing an overview of the state of the art concerning this innovative approach.

Finally, the PRISMA-P framework (Moher et al., 2015) should also be evaluated briefly. During the working process the present framework approved as a useful tool to systematically assess and compare interventions. The distinctly defined steps lead to organised working process with founded results. But is has to be mentioned that the PRISMA-P framework would work better with studies which are more homogenous with reference to their study design and measurements because this would improve the comparability of the results.

4.6 Further Research

During this systematic review several new questions concerning this new approach emerged. This indicates that much of further research is needed. Some ideas for future research will be addressed within this paragraph.

First, it is important to gain information about the usage of gamification within this field of psychology, since no information could be found in this systematic review. Therefore, another data base could be used for a conducting a search explicitly for interventions including gamification. Second, it is important to compare traditional interventions with modern interventions including games. The results would give information about the relative effectiveness of both approaches. Some of the interventions included in this systematic review also compared cooperative and competitive gaming during interventions. The results indicate that cooperative exergaming produces higher intrinsic motivation than competitive does. But competitive exergaming seems to have more positive influences on executive functioning than cooperative. That is why, this seems to be an important aspects which has to be investigated. This could be done by means of studies with a two group design, comparing the results of a competitive and a cooperative group. Another aspect to mention is that therapeutic serious games, like in I4, should be investigated more detailed because individuality of interventions is thought of as an important advantage. Finally, alternatives to games, such as listening to music during exercise as in I1, should be tested and compared because of the promising results of this intervention.

5. Conclusion

Finally, the following conclusions can be drawn. With reference to the first sub-question, the behaviours aimed to be altered by the interventions, it can be said that most of the interventions under investigation try to change a combination of physical activity and psychological aspects. The most important finding here is that serious games, exergames as well as educational games, successfully improve psychological factors, such as intrinsic motivation by combining serious issues like learning or exercising with gaming.

Referring to the second sub-question, the technology used within the interventions, it was found that most intervention make use of commercially available serious exergames. None of the interventions uses gamification. Another important finding is that therapeutic games differ from the commercially available ones because they can be individually adjusted. This could be an important advantage because individualisation is thought of as a factor of successful interventions.

Finally, the effectiveness of this kind of intervention seems to be promising. Nearly all interventions under investigation are categorised as more effective, according to the present fr amework. But it was found that the interventions have to make use of some guidelines with reference to the usage of the games. This is mandatory for the success of the intervention.

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