

Health Determinants Related to Digital Game Playing: A Systematic Review

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Abstract Digital games have become more and more popular in recent years. These games are part of everyday life for many people and offer a wide range of opportunities for user entertainment and experience. Despite their entertainment purpose, the increasing use of digital games has raised concern about the possible negative consequences for gamers, especially among children and adolescents. The purpose of this systematic review is to determine the relationship between digital game playing behaviour and health determinants in children and youth aged 12 – 24 years. Four electronic databases were searched. 39 studies met inclusion criteria and were included in the review. There is a wide base of evidence from different kinds of study designs which support the view that excessive digital game playing may cause harmful consequences for the health and health related behaviour of target users. These findings can be used to develop strategies that aim at reducing problematic game behavior and its negative consequences.

Keywords Digital games, Digital game playing, Adolescents, Psychological health, Physical health

1. Introduction

Computer games have become an extremely popular leisure activity among adolescents and adults. According to a study conducted by Interactive Software Federation of Europe (ISFE) twenty-five percent of the European online respondents play videogames at least once per week. The average player age is 35 years and 45% of all gamers are female. Networked games have become a larger part of everyday life, with an average 81% of European players playing games online [1].

The effects of excessive digital gaming, which refers to people who play digital games for a long time is a controversial issue. There is a lack of common understanding to the exact definition and name of the issue. Researchers have used a variety of terminologies to refer to the harmful use of digital games such as problem video game playing, problematic online game play, video game addiction, online gaming addiction, Internet gaming addiction, and compulsive Internet use [2]. Some studies have reported that excessive computer game playing may have an adverse effect on health status or health-related determinants among adolescents [3, 4, 5]. It is argued that

adolescents spend a notable amount of time using the computer, which is unfavorably linked with assimilation of health-related determinants such as life appreciation, health responsibility, social support, and exercise behaviour [3]. Studies have found a connection between excessive digital game play and sedentary [6] and aggressive behaviour [7, 8], as well as decreased academic performance [9] among children and adolescents. Moreover, a study by Ma and Jones [10] showed a connection in their findings between the computer viewing with wrist and forearm fracture risk in both sexes, while Mentzoni and colleagues [11] found a relationship between problematic use of video game and lower rates of life satisfaction, as well as increased levels of anxiety and depression.

Children and youth spend a lot of their time participating in sedentary activities like watching television (TV) or playing video games [12]. Adolescents engaging in sedentary pursuits are more likely to be at risk for lifestyle diseases [6]. Typical adults' diseases such as type II diabetes and cardiovascular diseases occur more commonly in childhood [13]. It is also argued that the prevalence of sedentary behaviors increases through adolescence [14]. That said, videogames have also proved a suitable tool for promoting health for cases such as childhood obesity [15] and physical health in the elderly [16].

Mostly adolescents play for entertainment and/or pleasure, because it is a challenge, or to escape from reality. For some subjects, the game becomes a priority, working as

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a compensation strategy or a motivation that they do not find in real life [17]. The time they spend playing directly influences their self-concept, i.e., the longer the time spent on the game, the lower the self-concept [18], and increases the probability of digital game addiction [19]. Other risk factors predicting this behavior are loneliness, low self-efficacy [20], anxiety, low self-esteem, poor general health and dissociation [21], and maladaptive cognition, shyness and physical problems [22]. Some personality factors such as aggressive behavior, sensation seeking, neuroticism, and trait and state anxiety also contribute to game addiction [23].

Digital game addiction is accompanied by some signs or symptoms such as concern with the game, social neglect, lies about what they have been doing, loss of interest in other leisure activities, social and psychological isolation, escape problems, defensive and anger responses [4], as well as social and psychological stress, reduced school performance, decreased sleep quality, and suicidal ideation[5]. For all these reasons, this issue should not be neglected, especially in adolescents, as a way to address maladaptive behaviors in adults.

Children and adolescents gaming have been identified as an important public health concern. A better understanding of the consequences of digital game play can be helpful in a variety of educational domains. By utilising a systematic literature review this investigation explores the impacts of

digital game playing for leisure on physical and psychological health. We provide an overview of the recent evidence on the relationships between physical and psychological health and associated factors in relation to digital game playing. The research questions investigated in this study include the following: i) What are the effects of playing digital games on adolescents' health and health behavior? and ii) What is the impact/role of digital game playing habits on psychological and physical health?

2. Methods

2.1. Study Inclusion Criteria

The review aspired to find all studies that examined the relationship between digital game play and specific health outcomes in children and youth (aged 12 to 24 years). Studies were included only if there was certain assessment of digital game behavior and its impacts on health. Digital game behavior was usually measured as engaging in digital game playing. Health indicators were chosen based on literature and interest to have features from an area of holistic health indicators (i.e. physical, psychological and social health). In order to be selected, studies also had to comply with the following inclusion criteria: be published in a peer-reviewed journal; and be available as full text in English language.

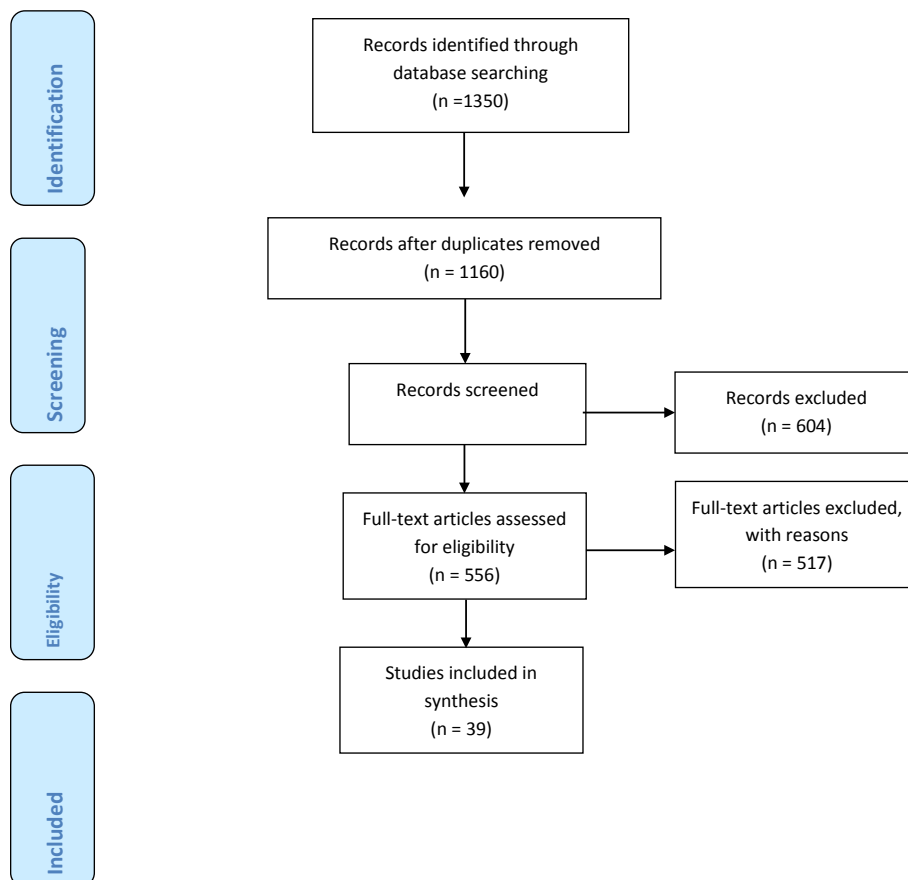


Figure 1. Results of the search strategy

2.2. Study Exclusion Criteria

Studies of “active games” and therapeutic games (e.g. Nintendo Wii, Microsoft Kinect, Sony Playstation Move etc.) were excluded. Articles without information about the combination of digital game playing and health-related impacts were excluded. Articles that were not available free of charge and papers reporting studies on card games (including online poker), as well as roulette and other casino games were also excluded. In addition, case studies, pilot studies, and studies focusing specifically on Internet addiction were excluded. Finally, studies that defined total media exposure and failing to indicate digital game play habits (ineligible measure of digital game playing), were excluded from the review.

2.3. Search Strategy

A systematic literature search was conducted using the databases PsycARTICLES, Psychology and Behavioral Sciences Collection (EBSCO HOST, 2007-2013), PubMed (2007-2013), CINAHL and Academic Search (EBSCO HOST, 2007-2013). Keywords were generated by examining the terminology used in empirical papers in the related literature. Search strategies were developed with the assistance of professional research librarians. Initial searches were conducted in these databases between June and August 2013. All specific search terms are included in Appendix 1. Using this search strategy, 1,350 articles were reviewed based on their abstracts and our inclusion criteria. All retrieved articles were independently reviewed by two researchers in order to identify articles that met the inclusion criteria. When they disagreed, the reviewers discussed and

achieved consensus. Duplicate articles were first removed manually. Full text copies were obtained for all articles meeting the inclusion criteria by at least one reviewer. The following information was abstracted from each of the eligible articles: study design, country where the study was conducted, participant age range, number of participants, assessment of game play habits and health outcomes.

2.4. Description of Studies

After de-duplication and the preliminary search of electronic databases, 1,160 potentially relevant articles were found (Figure 1). After assessing relevance based on title, abstract and keywords, 110 studies were included for full review, 39 of which fulfilled all criteria of inclusion. Two independent reviewers examined all full text articles. The majority of the studies included in this systematic review were cross sectional (n= 25). In total, data from 248 137 participants were included in this review. Studies ranged from 19 participants in intervention studies to 200 615 participants in cross sectional investigations. Articles were published between about a 7 year period from 2007 to 2013.

3. Results of the Literature Review

This section comprises a narrative summary of the literature review to provide context and clarity on relevant issues related to the relationship between digital gaming and psychological, social and physical health. This summary is organized into important themes of research that emerged from the structured review. Table 1 provides a summary of all studies included in the review.

Table 1. Summary of the studies

First author	Year	Total n analyzed	Country	Study design	Age range	Exposure	Main Outcomes
Grüsser SM [45]	2007	7,069	-	Cross sectional study	-	game play habits	AGG
Arriaga P [42]	2008	148	Portugal	Experimental study	18-46	VG, NVG	AGG, HO, HR
Olson CK [58]	2008	42	USA	A qualitative analysis	12-14	-	VIOL
Peng W [22]	2008	40	USA	Experimental study	-	VG	AGG
Wang CS [17]	2008	134	Taiwan	Cross sectional study	13-18	online game playing	LSS, SWLS
Wittmann M [44]	2008	2222	Spain	Cross sectional study	9-17	game play habits	BIS, AGG, STAXI
Holder MD [24]	2009	375	Canada	Cross sectional study	8-12	game play habits	SCS, PA, H
Ivarsson M [38]	2009	19	Sweden	Experimental study	12-15	VG, NVG	HR, HRV, PA, PS, SQ
Ohannessian CM [48]	2009	328	USA	Cross sectional study	14-16	game play habits	FF, SS, PC, DEPR, ANX, SU
Wack E [32]	2009	219	USA	Cross sectional study	18-32	game play habits	BMI
Allahverdipour H [31]	2010	477	Iran	Cross sectional study	12-15	game play habits	AGG, MHS
Choo H [28]	2010	2,998	Singapore	Cross sectional study	-	game play habits	SP, SS, SF
Desai RA [29]	2010	4,028	USA	Cross sectional study	14-18	game play habits	HB (various health aspects)

de Leeuw JRJ [30]	2010	475	Netherlands	A prospective study, Descriptive statistics	11-18	game play habits	SDQ, ALC, PA, FAS, BMI
Han DH [40]	2010	21	Korea	Experimental study	20-30	video game play	BA
Hoffman B [56]	2010	189	USA	Experimental study	-	game play habits	GO, AFF, NFG, POE
Melkevik O [34]	2010	200,615	Europe, North America	Cross sectional study	11-15	screen time, includes game play habits	PA
Padilla-Walker L [26]	2010	813	USA	Cross sectional study	-	game play habits	SP, QSR,
Swing EL [59]	2010	1,323	USA	Cross sectional study	-	game play habits	AP
Weaver E [60]	2010	30	-	Experimental study	14-18	pre-sleep video game playing	SSS, SOL, SA, CA, HR
Gentile DA [53]	2011	3,034	Singapore	A prospective study, Descriptive statistics	-	game play habits	SC, IMP, SoP, DEPR, SP
Ferguson CJ [46]	2011	603	USA	A prospective study, Descriptive statistics	10-14	game play habits	NLE, DEPR, AGG
Francis SL [36]	2011	434	USA	A prospective study, Descriptive statistics	5-13	sedentary behavior/game play habits	PA (moderate and vigorous)
Goldfield GS [39]	2011	282	USA	Cross sectional study	14-18	screen time/game play habits	BP, LIP
Hossini F [37]	2011	50	Iran	Experimental study	17-19	Exposed VG/NVG	SC
Kwon JH [54]	2011	1,136	Korea	Cross sectional study	-	IGA	R-I self, ES, NegMood, PR, P-CR, SPV
Lemola S [49]	2011	646	Germany, Austria, Switzerland	Cross sectional study	13-30	game play habits	SH, DEPR
Liau AK [52]	2011	2,154	Singapore	Cross sectional study	-	game play habits	IMP, ER
Mentzoni R [11]	2011	816	Norway	Cross sectional study	15-40	game play habits	SWLS, HADS, PA
Serrano-Sanchez JA [32]	2011	3,503	Spain	Cross sectional study	12-18	screen time/game play time	PA (moderate and vigorous)
Casiano H [27]	2012	9,137	Canada	Cross sectional study	12-19	screen time/game play time	DEPR, AD
Ferguson CJ [46]	2012	165	USA	A prospective study, Descriptive statistics	10-14	game play habits	NLEs, DEPR, AGG
Fraser AM [47]	2012	780	USA	Cross sectional study	18-29	game play habits	EC, PRO
Nakamura H [25]	2012	3,464	Japan	Cross sectional study	10-12	media use/game play habits	HS
Walther B [51]	2012	2,553	German	Cross sectional study	12-25	game play habits	SU, PF
Yen JY [57]	2012	2,348	Taiwan	Cross sectional study	-	game play habits	SA, DEPR
Bickham DS [33]	2013	91	USA	Cross sectional study	13-15	screen media use/game play habits	BMI
Ding W [41]	2013	41	China	Experimental study	14-17	IGA	IAS, ANX, DEPR, BIS
Leung ANM [55]	2013	626	China	Cross sectional study	9-15	game play habits	FQ, PMCU, SC, FS, SE, SWLS

AGG, aggressive behavior/thoughts; HO, hostility; VG, violent games; NVG, non-violent games; HR, heart rate; VIOL, violent; LSS, Leisure Satisfaction Scale; SWLS, The Satisfaction of Life Scale; BIS, Barratt Impulsiveness Scale; STAXI, Spielberger's State-Trait Anger Expression Inventory; SCS, Self-concept Scale; PA, Physical Activity; H = happiness, HR, heart rate; HRV, Heart Rate Variability; PS, Perceived Stress; SQ, Sleep Quality; FF, Family functioning; SS, Social Support; PC, Perceived Competence; SU, Substance Use; BMI, Body Mass Index; MHS, Mental Health Status; SP, School Performance; SS, Somatic Symptoms; SF, Social Functioning; HB, Health Behavior; SDQ, Strengths and Difficulties Questionnaire; ALC, Alcohol Use; FAS, Family Affluence Scale; BA, Brain Activity; GO, Goal Orientations; AFF, Affect; NFG, Need for Cognition; POE, Perceptions of Engagement; SP, Self Perceptions; QSR, Quality of Social Relationship; AP, Attention Problems; SSS, Stanford Sleepiness Scale; SOL, Sleep Onset Latency; SA, Sleep Architecture; CA, Cognitive Alertness; SC, Social Competence; IMP, Impulsivity; SoP, Social Phobia; DEPR, Depression; ANX, Anxiety; NLEs, Negative Life Events; BP, Blood Pressure; LIP, Lipids; SC, Salivary Cortisol; R-I self, Real-Ideal Self Discrepancy; ES, Escape from Self; NegMood, Current Negative Mood; PR, Peer Relationship; P-CR, Parent Child Relationship; SPV, Perceived Parental Supervision Scale; SH, Sleep Habits; ER, Emotional Regulation; HADS, Hospital Anxiety and Depression Scale; AD, Alcohol dependence; EC, Empathic Concern; PRO, Prosocial Behavior; HS, Health Status; SU, Substance Use; PF, Personality Factor; SA, Social Anxiety; IGA, Internet Gaming Addiction; IAS, Internet Addiction Scale; BIS, Barratt Impulsiveness Scale; FQ, Friendship Qualities; PMCU, Parental Monitoring of Computer Use; SC, Social Competence; FS, Friendship Satisfaction; SE, Self Esteem.

3.1. General health

Several studies concluded that the quantity of digital game use is related to risk behaviors and negative overall health outcomes, including happiness and positive self-concept [24], depression and sleeplessness, feeling ill at ease, dizziness, poor appetite, headache, abdominal pain, being short-tempered and negative thinking [25], greater drug use, drinking behaviors, and lower relationship quality with friends and parents [26]. In contrast, Casiano and colleagues [27] indicated that digital game playing was associated with decreased levels of various negative health consequences in youth, such as depression, binge drinking, and alcohol dependence.

In particular, there has been concern about pathological patterns of behavior with digital games and other computer- and Internet-related technologies. A study by Choo and colleagues [28] reported that pathological gamers had experienced more physical health problems (e.g. hand and wrist pains), more fights with parents over video games, getting too little sleep and being late for school, decreased social contact, neglecting self-care to play games (e.g. skipping meals, baths, toilet), and relying on friends to help with homework due to game playing. Indeed, similarly to

this study, problematic game playing or heavy game use have been associated with regular cigarette smoking, drug use, depression, serious fights[29], psychosocial problems, and less physical activity in secondary school children[30]. Moreover, increased game use has been linked with certain kinds of unhealthy features, such as somatic symptoms, anxiety, insomnia, worse mental health status and social dysfunction [31]. A study by Mentzoni and colleagues [11] showed that video gamers attained lower scores on self-reported health than respondents who did not use video games. Moreover, in this study problematic game use was linked to increased points on measures of anxiety and depression, and lower scores on satisfaction with life. Later in this review we will present further data regarding digital game playing and psychological health.

3.1. Physical Health

Of the 39 studies included in this review, 9 examined physical health. In relation to physical health, digital game players' physical health was usually determined based on two indicators. The primary measure was body mass index (BMI), which was typically determined from self-reports of weight and height. The second measure was derived from exercise habits, such as the number of days per week the subject engaged in vigorous exercise. Some studies were contradictory about the influence of video games on general physical condition. In a study on the relationship between the frequency of play and obesity, Wack and Tantleff-Dunn [32] found no causal relationship of gaming to increased body mass index. Recently, Bickham and colleagues [33] showed no significant association between duration of use of TV, video games or computers and BMI. In addition, a study by de Leeuw and colleagues [30] found no connection between heavy game use and BMI.

Melkevik and colleagues [34] found negative associations between gaming and moderate to vigorous physical activity (MVPA) and leisure time vigorous physical activity (VPA) for boys. Furthermore, a study by Serrano-Sanchez and colleagues [35] verified the supposition that the time spent in front of a screen was negatively linked with MVPA. Their results also showed that involvement in organized physical activity decreased the risk of excessive use of video games by 59% in boys. In another study, excessive game use was also significantly associated with decreased physical activity in secondary school children [30]. Francis and colleagues [36] evaluated sedentary behavior paths from childhood to adolescence. They reported an increase in adolescents' sedentary behavior – especially video game use – over the measurement periods. The results are also similar with previous knowledge reporting that MVPA decreases as children grow older. However, TV viewing and video game use seem to not decrease with adulthood in the same way.

3.2. Physiological Health

Five studies assessed the relationship between digital game playing and physiological health. Three studies examined the effect of computer game use on physiological

functions such as salivary cortisol concentration [37], heart rate variability [38] and blood pressure and lipids [39]. The results of cortisol concentration indicated that violent games had led to a notable growth in the level of salivary cortisol while playing, and that this level stayed stable in saliva sample tests twenty minutes after the game [37]. Non-violent games did not influence cortisol levels in the same way. The results of heart rate variability indicated that playing violent games caused different autonomic responses in boys compared to nonviolent gaming during playing and during the following night [38]. There was notable higher activity of the very low frequency component of the HRV and total power during the violent game playing. Very low frequency, low frequency, high frequency components as well as total power were significantly higher for the violent compared to the nonviolent condition during the night after playing. Correspondingly, playing video games has shown to influence blood pressure and lipids in obese adolescents by elevating them [39].

Two studies examined brain responses of Internet video-game play. Han and colleagues [40] perceived changes in brain activity in healthy university students in response to Internet video game cues after a continued period of game play. During a several week span of standardized video-game play, brain activity in the anterior cingulate and orbitofrontal cortex of the excessive Internet game-playing group (EIGP) increased in response to Internet video game cues. Ding and colleagues [41] investigated changes of functional connectivity (FC) in adolescents with Internet gaming addiction (IGA). In this study FC –measures were determined by using resting-state functional magnetic resonance Imaging (fMRI). These results indicated that adolescents with IGA generate different resting-state models of brain activity. These two studies verify the evidence of IGA as a behavioral addiction that may indicate the same kind of neurobiological abnormalities with other addictive disorders.

3.3. Violence and Aggression

In relation to psychological development, several cross-sectional studies of video game violence effects had been conducted, but none had employed well-validated measures of youth violence or considered video game violence effects in context with other influences on youth violence such as family environment and peer delinquency. In a study intended to analyze the influence of violent games on aggressive behavior using a sample of 148 participants, it was found that violent games evoked more hostile and aggressive behavior than non-violent games, regardless of the sex of the player and the use of virtual reality [42]. Links between real-life violence and violent games were indicated in another study where it was found that subjects with aggressive personality and manifesting violent behaviors tended to play more aggressive video games and use more violent actions, such as punches, kicks, and shots [43]. Moreover, time spent playing video games was shown to be related to aggression [44, 31]. In contrast, a study by Grüsser

and colleagues [45] indicated that aggressive behavior is unrelated to excessive gaming. Results from a longitudinal study by Ferguson and co-authors [46] provided evidence against the harmful effects of video game violence. The result showed that playing violent games was not associated with pathological aggression reported by the child or parent. A study by Fraser and colleagues [47] found that there was a negative association between playing violent video games and social interactions with family. In addition, this study also found a connection between violent video gaming and low empathic concern in both genders.

3.4. Psychological Health

Regarding psychological health, two studies reported that digital game playing was not associated with depression [27, 48]. In contrast, Nakamura and co-authors [25] found an association between the time spent using games and depression in their cross-sectional school-based population survey. Conventional late computer game playing was also associated with a probability of depression in adolescents and young adults [49]. Furthermore, adolescents with problematic game playing recorded that depression was more likely [29]. The results of this study also suggested that adolescents with problematic game playing were more likely to be involved in other risk behaviors such as smoking, drug use and violence. Wang and co-authors [50] reported that a strong commitment to online games had a negative effect on adolescent life satisfaction.

This review shows that pathological digital game playing can lead to negative psychosocial consequences, such as aggression, loneliness, lower self-esteem and social self-efficacy [51]. Correspondingly, higher levels of impulsivity and lower levels of self-regulation appear to act as predictors of pathological video gaming [52]. Moreover, a study by Gentile and co-workers [53] found that youth with characteristics of impulsive personality, lower social competence and poorer emotional regulation skills were more probable for risk of becoming pathological gamers. The same study provided also displayed evidence that depression, anxiety, social phobias and lower school performance were potential outcomes of pathological game playing. Kwon and co-workers [54] reported that the escape from self theory might be one clear explanation for adolescents' Internet game addiction.

Although there are some discrepancies, the importance of games in psychosocial adjustment has also been studied. Leung and Chang [55], in a study whose main objective was to explore associations between friendships and online bullying, recognized that best friends were the ones with whom adolescents played massively multiplayer online games (MMOGs). Digital game players also reported that the game playing may deliver a pleasant experience; it may satisfy recreational and social needs, and the cognitive and affective outcomes of gaming typically resulted in feelings of satisfaction, accomplishment, and contentment [56]. A study by Yen and co-workers [57] demonstrated that social anxiety is lower during online interaction than during

face-to-face conversation. Thus online interaction proved to be an alternative option of social interaction for users with social anxiety. In contrast, video game use was linked to more negative relationships with friends and parents [26]. Furthermore, the same study indicated that video game use was associated with deteriorated self-worth and with lower experienced social acceptance in women.

A study by Olson and co-workers [58] found that boys used games to experience fantasies of power and fame, to explore and master what they perceive as an exciting and realistic environment, to work through angry feelings or relieve stress, and as social tools. In contrast, one study provided evidence that digital game exposure had effects on attention problems [59]. In relation to sleep, digital game playing did not appear to have a significant impact; one study showed that pre-sleep digital game playing had only a minor influence on the ability to fall asleep [60].

4. Discussion and Conclusions

Digital games have become a prevalent perspective of the lives of young people. The aim of this study was to describe typical consequences of digital game behavior on individuals' health among adolescents and young adults. This study synthesizes the results of 39 studies. It finds that digital game use has been evaluated for a wide variety of health-related purposes.

The negative relationship between television viewing and obesity in children and adolescents is well known [61]. In contrast to these findings, our study regarding the association between electronic game playing and obesity is not so evident. However, exposure to electronic game playing is often implicated in obesity crisis because it may promote sedentary behavior and increase daily calorie intake and beverages that are low in nutritional value [62].

This review demonstrates that there is a need to encourage and support increases in physical activity. Children and youth should try to minimize the time they spend engaging in television viewing and digital game playing among other media activities. Physical activity seems to decrease as children grow older, but digital game use does not appear to decrease in the same manner with maturity [36].

Our review demonstrates that seated digital game playing is associated with increased blood pressure and lipids in obese adolescents [39]. The study also provides support for the assumption that seated digital game playing – especially with violent content – may cause acutely increased sympathetic tone, perhaps due to the excitement, stress and concentration required for successful game playing [37, 38, 39]. Because digital game playing promotes sedentary behavior, this habit may increase risk of developing cardiovascular diseases in obese adolescents in the long term. Thus it is important to encourage adolescents to pursue other hobbies and interests as a means to promote cardiovascular health.

Although the prevalence of problematic game playing is

not so common it is not irrelevant [5, 11, 19]. Our review shows distinct marks, in which problematic game playing is associated with poorer health. The review results suggest that adolescents with problematic game playing are more likely to also engage in other risk behaviors.

Given the potential negative health consequences of pathological digital game playing, knowing its etymology may lead to the development of valuable treatments. However, it would be difficult to prove differences between risk factors and the outcomes of pathological game playing. According to the findings, adolescents may use online games as a way of coping with stressors [58]. Adolescents may become addicted to Internet games as a means to escape from self and reality [54]. Thus they seem to use digital game playing as a method for emotion regulation in order to decrease negative feelings. Higher levels of impulsivity are related to lower levels of self-regulation, whereas these factors may be associated with higher levels of pathological digital game playing [52]. Findings provide support that greater amounts of digital game playing, lower social competence, and greater impulsivity may predict pathological gaming while depression, anxiety, social phobias, and lower school performance appear to be consequences of pathological game playing [53]. This study also cautiously suggests that brain changes due to excessive Internet video game play may indicate same kind of neurobiological abnormalities with other addictive disorders. Correspondingly, personality characteristics such as irritability/aggression, social anxiety, ADHD, and low self-esteem have also been associated with problematic digital game playing [51].

The review findings suggest that the way leisure-time is spent relates to aggression. The more time spent playing video games, the greater the impact of this behavior may have on aggression [31, 44]. However, no clear understanding has been achieved concerning the impact of violent video games on aggression, particularly in terms of long-term impact.

This systematic review summarizes the current evidence examining the relationship between digital gaming and a series of health indicators. The findings of the current review may add to the base of knowledge needed to develop strategies that aim at diminishing problematic game behavior. This study summarizes that increased time with digital game playing is associated with negative health outcomes in boys and girls. Further research using random sampling and multiple settings is required to confirm and define the results. The findings could be used to develop health strategies aimed at reducing unhealthy behaviors and to diminish obstacles to promote healthy lifestyles in youth.

5. Limitations

Some limitations of the papers reviewed should be noted. First, most of the reviewed studies had a cross-sectional design, which means that we were not able to draw

conclusions about any cause-effect relationship. The other main limitation was the self-reported measures used in most of the studies. Reported bias means that some of the results might be either under-reported (e.g. gaming habit) or

over-estimated (e.g. physical activity). The samples used in this review only included adolescents, which is why the results are not representative of the whole population.

Appendix 1. Database Search Strategy

<i>Database</i>	<i>Search string used</i>
PsycARTICLES	gaming*; gaming and eating; gaming and health and adolescence; gaming and sleep; multiplayer and teenagers and students; video games and health and benefits.
Psychology and Behavioral Sciences Collection (EBSCO HOST)	gaming*; gaming and eating; gaming and health and adolescence; gaming and sleep; multiplayer and teenagers and students; video games and health and benefits.
PubMed	"video game*" OR gaming OR "digital game*" OR "console game*" OR "virtual world*" OR "computer game*" OR "internet game*" OR "mobile game*" OR "electronic game*" OR "online game*" OR "multiplayer game*" <p style="text-align: center;">AND</p> "health behavior" OR "health behaviour" OR "health related behaviour" OR "health related behavior" OR "health aspect*" OR "effect on health" OR "well-being" OR "quality of life" OR "life satisfaction" OR welfare OR "health impact*" OR "health outcome*" OR "health attitude" OR "physical health" OR "psychological health" OR "mental health" OR "health responsibility" OR fatigue OR stress* OR somatic OR "psychosomatic symptom*" OR personality OR eating OR "food consumption" OR diet OR sleep OR "physical activity" OR "physical fitness" OR exercise OR "cardiorespiratory fitness" OR disorder* OR symptom* <p style="text-align: center;">AND</p> teenager* OR adolescent* OR student* OR youth <p style="text-align: center;">NOT</p> "therapeutic play*" OR "therapeutic game"
Cinahl and Academic Search (EBSCO HOST)	"video game*" OR gaming OR "digital game*" OR "console game*" OR "virtual world*" OR "computer game*" OR "internet game*" OR "mobile game*" OR "electronic game*" OR "online game*" OR "multiplayer game*" <p style="text-align: center;">AND</p> "health behavior" OR "health behaviour" OR "health related behaviour" OR "health related behavior" OR "health aspect*" OR "effect on health" OR "well-being" OR "quality of life" OR "life satisfaction" OR welfare OR "health impact*" OR "health outcome*" OR "health attitude" OR "physical health" OR "psychological health" OR "mental health" OR "health responsibility" OR fatigue OR stress* OR somatic OR "psychosomatic symptom*" OR personality OR eating OR "food consumption" OR diet OR sleep OR "physical activity" OR "physical fitness" OR exercise OR "cardiorespiratory fitness" OR disorder* OR symptom* <p style="text-align: center;">AND</p> teenager* OR adolescent* OR student* OR youth <p style="text-align: center;">NOT</p> "therapeutic play*" OR "therapeutic game"

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