Journal of Public Health
https://doi.org/10.1007/s10389-022-01788-y

ORIGINAL ARTICLE

Associations between digital gaming behavior and physical activity among Finnish vocational students

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Received: 3 October 2022 / Accepted: 27 November 2022

Abstract

Digital gaming is considered to be a major sedentary lifestyle among youth. The time spent on digital gaming may also affect the physical behavior of young adults.

Objective This study aimed to investigate the associations between various characteristics of digital gaming behavior (i.e., gaming time, device, and game type) and participation in physical activity among Finnish vocational students.

Materials and methods The research employed a cross-sectional survey design. The analyzed sample consisted of 773 students (455 males, 318 females) from eight vocational school units in Northern Finland who regularly played digital games. Data were collected via an online self-reported questionnaire, which included questions concerning average weekly time spent on digital gaming, preferred device, favorite types of games, and physical activity.

Results The students spent an average of two hours each day playing digital games. Males preferred to play using personal computers (PCs), whereas mobile gaming was more popular among females. Shooter (42.4%) and entertainment (64.2%) games were the most popular game types among males and females, respectively. The results revealed that male gender and PC gaming were both positively related to physical inactivity among vocational school students. A preference toward sport games was inversely related with physical inactivity.

Conclusion The presented findings can be utilized to develop interventions that target the prevention of sedentary behavior among vocational students. Further longitudinal studies will be required to reliably assess the relationship between digital gaming and physical activity.

Keywords Digital gaming · Physical activity · Students · Youth

Introduction

Physical activity (PA) is acknowledged as the foundation for physical progress among newborns, children, and adolescents approaching adulthood (Ward et al. 2007; Hands et al. 2009; Robinson and Goodway 2009). The health benefits of physical activity are well documented (Warburton and Bredin 2017). Students in vocational education should also have sufficient levels of physical activity to ensure their well-being during studies and work ability after graduation. There is prior evidence that effective lifestyle interventions take an integrated approach to lifestyle; for example, promoting physical activity should be linked to decreasing sedentary behavior (Warburton and Bredin 2017). The results of several studies suggest that physical activity levels decrease throughout childhood, and continue to decline during adolescence (Farmer et al. 2017; O'Donovan et al. 2010). The transition from primary school to secondary education is a critical period in an adolescent's life, and may be related to noticeable changes in physical activity levels. According to one systematic review, sedentary behavior increased during this transition (Pearson et al. 2017), while European surveys have shown that PA levels among youth have decreased

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Published online: 11 December 2022

and the percentage of obese adolescents has dramatically increased in the past 30 years (Balakrishnan 2022; Ledergerber and Steffen 2011).

According to PA guidelines, adolescents should have at least 60 min of moderate- to vigorous-intensity activity (MVPA) each day to promote their health (Federal De Pelotas et al. 2012; Tremblay et al. 2011; WHO 2010, 2020a, b). Unfortunately, the majority of adolescents do not meet the current physical activity guidelines (Guthold et al. 2020). Furthermore, Finnish vocational education students meet these recommendations more rarely than Finnish high school students (15.4% vs.17.5%) (Finnish Institute of Health and Welfare 2021). Other research has reported that high school students are also more physically active than vocational school students (Hankonen et al. 2017; Heradstveit et al. 2020). According to WHO recommendations, adults should have at least 150 min of moderate-intensity or 75 min of vigorous-intensity physical activity each week (WHO 2020a, b). According to recent data, nearly half of the adult population (48.4%) in the European Union (EU) was completely inactive (i.e., did not engage in any aerobic physical activities during a typical week), while 31.7% exercised for at least two and a half hours per week during their leisure time (Eurostat 2019).

MVPA profoundly affects human energy expenditure (Brownson et al. 2005; Brooks et al. 2004). A human metabolic equivalent (MET) is defined as the energy cost of sitting quietly, and is equivalent to caloric consumption of 1 kcal/kg/hour. In comparison with sitting quietly, individual caloric consumption is three to six times higher when a human is moderately active (3-6 METs) and more than six times higher when a human is vigorously active (>6 METs) (Westerterp 2017; Schutz et al. 2001; Matthews et al. 2008). The documented MVPA health benefits for humans include improved physical fitness (both muscular strength and cardiorespiratory fitness), condensed body fat, favorable cardiovascular and metabolic disease risk profiles, improved bone health, and reduced symptoms of depression (Guo et al. 2016; Reiner et al. 2013; WHO 2010; 2020a, b).

PA should not be mistaken with "sport" or "exercise," as these types of activities are planned, controlled, repetitive, and purposeful. A generally accepted PA definition is any bodily movement produced by the skeletal muscles that substantially increases resting energy expenditure (Bouchard et al. 2007; Caspersen et al. 1985). As such, PA includes sport and exercise, along with other activities which require bodily movement, e.g., playing, working, active transportation, house chores and recreational activities (WHO 2010).

Certain individuals engage in sedentary behaviors (commonly called "screen time") over PA (Cheval et al. 2018; Lee et al. 2016; Lieberman 2015) as their social and physical environment tends to support this kind of living. Sedentary behavior refers to any activities that do not substantially increase energy expenditure above the resting level (Pate et al. 2008). Sedentary behavior is not synonymous with physical inactivity (van der Ploeg and Hillsdon 2017), although these terms are used interchangeably. This is because individuals who spend lots of time on sedentary behaviors can still be physically active. The term physical inactivity describes individuals who are performing insufficient amounts of MVPA (Tremblay et al. 2017). Sedentary behaviors, such as digital gaming, watching television, using a mobile phone or browsing high-speed internet entertainment, have become a favorite mode of inactive entertainment in people's daily living (Biddle et al. 2010; Oliver et al. 2012). This is worrying, as sedentary behaviors and physical inactivity are strongly associated with many major diseases, such as obesity, diabetes, and cardiovascular disease (O'Brien et al. 2018 ; Carrel et al. 2005 ; Magnussen et al. 2011; Pate et al. 2006). In this way, it is not surprising that physical inactivity is responsible for 9% of premature mortality on a global level (Lee et al. 2012). Uncontrolled sedentary behavior during early childhood is also linked with short- and long-term psychological and physiological health consequences (Männikkö et al. 2017; Hinkley et al. 2014; Katzmarzyk et al. 2009).

Digital gaming is an accurate example of a sedentary activity, as the energy expenditure associated with digital gaming is only 1.5 MET, which meets the MET value for sedentary behavior (Tremblay et al. 2017; van der Ploeg and Hillsdon 2017). Digital gaming has become a highly prevalent sedentary activity among youth worldwide (Newzoo 2021). In Finland, 36.4% of the population under 20 years of age plays digital games daily, with 69.8% playing digital games at least once a week (Mäyrä et al. 2018). A digital game can be defined as an electronic and dynamic system that is played with the assistance of a computer or other electronic device (Juul 2005; Adams and Dormans 2012). Digital games react to a player's activity, and include elements such as pulsating colors, moving images, advanced graphics, and sound stimuli (Adams and Dormans 2012). Modern games can be very addictive, with the gaming industry continuing to develop games that are more and more realistic (Griffiths and Nuyens 2017; Sandbrook et al. 2015). For this reason, gaming activity can easily intensify into a marathon session, with non-stop gaming periods lasting over 10 hours no longer a rare occurrence (Kovess-Masfety et al. 2016). A flow state, during which an individual loses track of time, may occur if the digital game is intense enough to effectively exclude external stimuli (Holden et al. 2018; Hull et al. 2013; Huang et al. 2011; Sherry 2004). Brain imaging research has found that stimulating the brain via screens and gaming is as dopaminergic (dopamine-activating) as sex, gambling, and the use of addictive substances; the mechanistic explanation is that the gaming experience overloads the brain's pleasure center

with multiple stimuli (Kuss and Griffiths 2012; King and Delfabbro 2009; Wu et al. 2012).

An advanced feature of digital gaming is the ability to build social connections in a digital social environment (Domahidi et al. 2014; Chen 2009; Ducheneaut and Moore 2005). Famous theoretical frameworks propose that humans achieve well-being and happiness by satisfying basic psychological needs for social connectedness in life (Lubans et al. 2016; Kowert and Oldmeadow 2013). Older games and consoles supported only single player games, which could isolate players from social interactions (Kowert et al. 2014). In contrast, PA has historically been key to improving well-being via social interactions, as many PA-related actions require several participants (de la Haye et al. 2011; Macdonald-Wallis et al. 2011; Bailey 2006). As such, gaming enthusiasts who previously satisfied their need for social connections through PA can now enjoy social interactions via online games, especially massively multiplayer online role-playing games (MMORPGs), which provide a digital version of a social environment that does not include real-life problems (Zhang et al. 2017; Yee 2006). As such, players can use MMORPGs to build a second, virtual life. Gamers can even create their own flawless character for social interaction, find new friends, and develop affinities with their chosen long-term social groups; this has been well documented in the MMORPG "World of Warcraft" (Kneer et al. 2014; Chen 2009; Cole and Griffiths 2007).

The time that adolescents spend on digital gaming is not expected to decrease in the future, as these games are no longer just for leisure time and fun (von der Heiden et al. 2019). The gaming industry has recently appeared to take another massive leap forward in the form of electronic sports (Esports) (Holden et al. 2018; Parshakov and Zavertiaeva 2018). Esports most commonly take the form of organized, multiplayer video game competitions, potentially between professional players and other gamers (Hamari and Sjöblom 2017; Heaven 2014). Esports have become highly popular in the past few years, with the number of fans growing fast (Parshakov and Zavertiaeva 2018). This form of competition is especially attractive to young people who dream of making millions by just playing digital games (Jiow et al. 2018). The world-wide Esports audience (participants and viewers) is anticipated to reach upward of 435 million people by 2019 (Holden et al. 2018).

While several studies have attempted to determine whether active video games help to promote PA, relatively few studies have gathered data to assess the relationship between passive, more traditional digital gaming and PA (Ballard et al. 2009). Most of these studies, including an extensive meta-analysis by Marshall et al. (2004), have found that time spent in sedentary behaviors is mostly uncorrelated with PA. Only a few studies have reported a partial link between digital gaming and PA. For example, a cross-sectional Chinese study (N = 10214) reported a relationship between computer gaming (over 4h) and physical inactivity among adolescent boys between the age of 11-18 years ($p < 0.05$) (Chen et al. 2014). The same association was not found among girls. Furthermore, a meta-analysis (N = 200165) focusing on Northern Europe and North America registered a negative connection between digital gaming and PA. However, the study showed that digital gaming was not consistently associated with lower levels of PA, as there were regional and between-sex differences (Melkevik et al. 2010). There are even results that digital gaming and PA are positively related. A Canadian cross-sectional study (N = 7982) presented that boys aged 12-18 years who played over six hours of computer games a week were more physically active than boys of the same age group who did not play computer games (Koezuka et al. 2006); this result, however, was not statistically significant.

The proposition that digital gaming predisposes adolescents to an increased risk for physical inactivity is based on the fact that digital gaming sessions undoubtedly displace some time that could be used for PA and MVPA (Holden et al. 2018; Davies and Blake 2016; Hull et al. 2013; Dini 2012; Ballard et al. 2009; Vandewater et al. 2004). Moreover, the enormous popularity of digital gaming suggests that adolescents could well prefer digital gaming to physical activities (Cheval et al. 2018; Lee et al. 2016; Lieberman 2015; Oliver et al. 2012; Foley and Maddison 2010; Biddle et al. 2010).

Objectives

Only a few studies have investigated specific gaming-based behaviors in relation to physical inactivity among young adults. This study aimed to investigate the association between various characteristics of digital gaming (i.e., gaming time, preferred device, and game type) and participation in physical activity among Finnish vocational students. It was expected (Hypothesis 1) that the amount of gaming time would be related to physical inactivity during early adulthood. Furthermore, the current study investigated whether specific game types, including PC and online-gaming (particularly related to elements of strategy games), have a stronger effect on students' physical inactivity. In this study, physical inactivity was defined as less than two hours of physical activity per week (PA or MVPA).

Methods

Study design and participants

This Finnish cross-sectional study is part of a larger health study including vocational students that was conducted in September 2017 (Männikkö et al. 2020). The original sample

included 1333 vocational students studying in eight units of vocational upper secondary education in northern Finland. This form of education lasts three years, upon which graduating students are eligible to continue with higher education (Ministry of Education and Culture 2018). The students were studying the following fields: culture; natural resources and environment; social science, business and administration; social services, health and sports; technology, communication and transport; tourism, catering and domestic services; and natural resources. Data were collected using an online survey that was administered with the assistance of staff members. After excluding the surveys with incomplete answers and/or that represented non-digital gamers (based on a participant's self-report of the past 12 months), the subsample used in this study included 773 vocational students.

Measures

The self-reported online questionnaire consisted of three parts: sociodemographic and living arrangements of the participants; digital gaming behavior; and health-related behavior and qualities (Männikkö et al. 2020). The present study analyzed data concerning digital gaming time, device, and game type, along with PA and gender. In this study, the concept of digital gaming included all types of digital gaming (including that performed on PCs, gaming consoles, a mobile phone, tablets, and laptops), but not gambling. Average digital gaming time was defined as the number of minutes per weekday and weekend spent on gaming, and was assessed through two questions:

(1) "About how many minutes a day (Monday–Friday) do you usually play digital games in your free time?"
(2) "About how many minutes a day (Saturday and Sunday, along with vacations) do you usually play digital games in your free time?"

The devices used for digital gaming, along with the types of games, were evaluated through the following questions:

(1) "Which device do you prefer when gaming (console, tablet, mobile phone, PC, other)?"
(2) "What kind of games do you usually play (entertainment, single player, vehicle simulation, strategy, sports, shooter, multiplayer online battle, MMORPG)?"

The questionnaire included one question to assess overall PA and MVPA. PA contains all activities that increase heart rate, whereas MVPA activities require a participant to feel out of breath some of the time (e.g., sports, playing with friends, active commuting to school, and small acts of everyday life). PA was assessed using the question: "During a regular week, how many of the days were you physically active for at least 60 minutes?". The response categories for the PA question were as follows: "None"; "one day"; "two days"; "three days"; "four days"; "five days"; "six days"; and "seven days".

MVPA was evaluated using the question: "How much vigorous exercise do you have outside of school hours (you breathe and sweat at least mildly) per week?". This question had the following response categories: "Not at all"; "About half an hour"; "About an hour"; "2–3 hours"; "4–6 hours"; and "7 hours or more". Prochaska et al. (2001) found this question to be reliable and show acceptable validity when compared with accelerometer data. In the analysis, these categories were collapsed according to the Finnish recommendation for health-enhancing PA for youth.

Ethical considerations

This study was performed in accordance with the Declaration of Helsinki. The study was conducted with the permission of the school's administrators. Students were informed about the study and provided passive consent via an informational page. Participation was voluntary, and the anonymity and privacy of participants were guaranteed.

Data analysis

Data were analyzed using SPSS for Windows (version 28; SPSS Inc., Chicago, IL). The participants' demographic information, physical characteristics, and PA were presented using descriptive statistics and frequencies, while digital gaming characteristics were described through mean and SD (standard deviation) values. Differences in demographic characteristics and prevalence rates between genders were analyzed with the chi-squared test. An independent t-test was used to determine the association between a genre and game playing time. Moreover, two binary regression analyses were conducted with the respective physical inactivity patterns (i.e., insufficient MVPA and PA) as the dependent variables. Gender and gaming behavior characteristics (preferred device, favorite game type, and average daily gaming time) were entered as independent variables in the model. For categorical variables (gender, gaming device, game type), the first item served as the reference category. The threshold for statistical significance was set as $p < 0.05$.

A binary logistic regression was conducted to predict the dependent variables (PA and MVPA) with the following covariates: sex; game type; device; and gaming time. PA values were categorized as either "PA" (PA ranging between 1 to 7 days per week) or "Insufficient PA" (PA between 0-1 days per week). MVPA values were categorized as either "MVPA" (MVPA between 2 to >7 hrs) or "insufficient MVPA" (MVPA<2hrs). The cutoff point of under two hours was chosen because the Physical Activity Guidelines

Table 1 Prevalence of digital gaming between genders

Digital gaming	Male		Female		Total	
	n	%	n	%	n	%
Device						
Console	165	36.3	50	15.7	215	27.8
PC	190	41.8	44	13.8	234	30.3
Smartphone	93	20.4	209	65.7	302	39.1
Tablet, portable device, other game platform	7	1.5	15	4.7	22	2.8
Game type						
Entertainment	39	8.6	204	64.2	243	31.4
Single player	16	3.5	24	7.5	40	5.2
Vehicle simulation	36	7.9	1	0.3	37	4.8
Strategy	13	2.9	4	1.3	17	2.2
Sport	62	13.6	9	2.8	71	9.2
Shooter	193	42.4	25	7.9	218	38.2
Multiplayer online battle	47	10.3	8	2.5	55	7.1
MMORPG	11	2.4	6	1.9	17	2.2
Other	38	8.4	37	11.6	75	9.7

recommend that adults should participate in moderate to vigorous physical activity (MVPA) for at least 150 minutes per week. The "average weekly use" of gaming was generated for each media activity [(weekday x 5) + (weekend day x 2)]. Minutes were converted to hours.

Results

Descriptive characteristics of participants

The subsample used in this study consisted of 773 students (455 males, 318 females). The male participants had an average age of 17.2 years (SD = 4.08), while the female participants had an average age of 18.1 years (SD = 4.82). The participants estimated that they engaged in 1.66 hours (SD = 2.13) of digital gaming on a typical day. The male participants spent significantly more time on digital gaming (2.3 h) than female participants (0.9 h) ($t(705) = -8.734$ $p < 0.001$).

Participants' digital gaming and physical activity characteristics

Male participants preferred the PC (41.8%) for digital gaming, with a gaming console (36.3%) as the second most popular option. Female participants preferred smartphones (65.7%) and consoles (15.7%) (Table 1). The least popular devices for digital gaming among all participants were tablets and portable devices (other than smartphones). Male participants preferred shooter games (42.4%), while female participants preferred entertainment games (64.2%). MMORPG games were, surprisingly, the least favorite game type for both males and females. Statistically significant between-gender differences were found for preferred device (χ^2 (3), = 181.4, $p < 0.001$) and game type (χ^2 (8), = 335.9, $p < 0.001$).

According to the questionnaire results, male students were more likely to participate in PA than female students (χ^2 (7), = 47.9, $p < .001$) (Table 2). More specifically, 15.8% of males were active every day of a normal week. Only 4.4% of females reported that they were active each day of the week. Furthermore, 7.7% of males reported "No activity," with the corresponding share for females being 10.1%. Male participants also showed significantly higher MVPA levels than female participants (χ^2 (5), = 34.5, $p < 0.001$). For example, 17.4% of the male participants had seven hours or more of MVPA during the regular week, while the corresponding share for female participants was 5.0%. Moreover, only 8.8% of the male participants reported having no MVPA during the regular week, while 12.6% of female participants reported having no MVPA during the regular week.

Associations between gaming behavior characteristics and physical inactivity

A total of two logistic regressions (Table 3) were conducted to identify how sex, device, game type, and gaming time influence the likelihood that a participant shows insufficient MVPA or PA. The logistic regression models were statistically significant ($X^2(13) = 57.051$, $p < 0.001$ for MVPA and $X^2(15) = 34.178$, $p = 0.001$ for PA). The model explained 10.4% (Nagelkerke R^2) of the variance in insufficient MVPA and correctly classified 58.1% of cases. The model for

Table 2 Prevalence of physical activity between genders

PA	Male		Female		Total	
	n	%	n	%	n	%
PA during regular week						
0 day	35	7.7	32	10.1	67	8.7
1 day	29	6.4	44	13.8	73	9.4
2 days	63	13.8	61	19.2	124	16.0
3 days	72	15.8	68	21.4	140	18.1
4 days	75	16.5	48	15.1	123	15.9
5 days	77	16.9	31	9.7	108	14.0
6 days	32	7.0	20	6.3	52	6.7
7 days	72	15.8	14	4.4	86	11.1
MVPA during regular week						
Not at all	40	8.8	40	12.6	80	10.3
About half an hour	50	11.0	50	15.7	100	12.9
About an hour	72	15.8	71	22.3	143	18.5
2–3 hours	113	24.8	82	25.8	195	25.2
4–6 hours	101	22.2	59	18.6	160	20.7
7 hours or more	79	17.4	16	5.0	95	12.3

Table 3 Risk odds for insufficient physical activity

	Digital gaming and physical activity			
	Insufficient MVPA		Insufficient PA	
Variable	OR (95% CI)	*p*-value for increased odds	OR (95% CI)	*p*-value for increased odds
Sex		***p*=0.002**		***p*=0.001**
Female (reference)	1		1	
Male	**.49 (0.32–0.77)****		**.39 (0.22–0.69)****	
Device		***p < 0.001***		*p*=0.061
Console (reference)	1		1	
PC	**2.32 (1.49–3.62)*****		**2.14 (1.18–3.86)***	
Smartphone	1.37 (0.86–2.18)		1.35 (0.71–2.55)	
Portable device, other	0.60 (0.20–1.79)		2.25 (0.70–7.23)	
Game Type		*p* = 0.076		*p*=0.272
Entertainment (reference)	1		1	
RPG	1.49 (0.69–3.19)		1.64 (0.66–4.05)	
Simulator	1.12 (0.49–2.59)		0.52 (0.11–2.47)	
Strategy	2.55 (0.84–7.76)		2.22 (0.62–7.88)	
Sport	**0.39 (0.17–0.89)***		0.61 (0.19–1.96)	
FPS	1.18 (0.68–2.06)		1.78 (0.87–3.65)	
MOBA	1.48 (0.71–3.07)		1.96 (0.80–4.80)	
MMORPG	0.71 (0.23–2.14)		0.79 (0.16–3.85)	
Other	0.86 (0.46–1.61)		0.89 (0.39–2.00)	
Average gaming time (weekly)	0.97 (0.89–1.05)	*p* = 0.526	0.95 (0.85–1.05)	*p*=0.347

insufficient PA explained 7.8% (Nagelkerke R^2) of the variance and correctly classified 82.7% of cases.

Females were more likely to have lower levels of MVPA and PA than males. The type of device was also associated with higher odds of physical inactivity. Participants who used PCs while gaming were more than two times more likely to exhibit insufficient MVPA and PA than participants who used game consoles. Participants who played sport

games were less likely to exhibit insufficient MVPA than participants who played other types of games. Game types that were related to online, shooter, and strategy elements (i.e., RPG, strategy, FPS, and MOBA) were linked with an increased, albeit non-significant, likelihood of decreased levels of physical activity (insufficient MVPA and PA).

Discussion

Early adulthood is a critical period in the development of screen-based sedentary behaviors that may have significant long-term implications. Consequently, the aim of the present study was to investigate the associations between the characteristics of digital gaming (i.e., gaming time, preferred device, and game type) and participation in leisure time physical activity among Finnish vocational students. The results showed that certain characteristics, namely male gender and PC gaming, were positively associated with insufficient levels of PA, whereas playing sports video games was inversely associated with insufficient levels of PA. Previous research has shown inconsistent findings regarding the relationship between gaming engagement and either physical activity or sedentary behaviors (Huard Pelletier et al. 2020).

Contrary to Hypothesis 1, the current study did not identify a significant relationship between total gaming time and insufficient overall PA and MVPA. While males spent a lot of time on digital gaming, this did not generally come at the expense of PA or MVPA. The displacement hypothesis suggests that youth who engage in digital media activities can displace the time they use on physical activity during leisure time (Lizandra et al. 2019). The results presented in the present study are not applicable to this context because only data concerning gaming behavior, and not other forms of screen-based activities, were collected.

The results revealed that females spend significantly less time each day on digital gaming than males, which is in line with what has been reported in previous studies (Kim et al. 2016; Paulus et al. 2018). In addition, both insufficient physical activity and a sedentary lifestyle were more prevalent among female students than male students. Moreover, 9.4% and 18.5% of the student participants engaged in insufficient PA (at most one day of PA per week) and MVPA (less than 150 minutes per week), respectively. Previous research has presented inconsistent findings concerning gender differences in physical activity levels and sedentary behavior (O'Donoghue et al. 2016). At present, approximately one in four adults around the world are physically inactive (WHO 2022). Previous evidence has shown that a sedentary lifestyle, which is linked to health-related behaviors, is influenced by multiple factors, including individual-level (e.g., older age, low socioeconomic status), behavioral (e.g., consumption of high-calorie snacks, smoking, smartphone use), psychological (e.g., depressive symptoms, anxiety, stress), and environmental (e.g., a lack of PA facilities) determinants (O'Donoghue et al. 2016).

The present study showed that females prefer to use smartphones (65.7%) for gaming, with casual games (entertainment; 64.2%) emerging as the favored game type. Males preferred a PC for gaming, with shooter games emerging as the favored game types. These findings are in line with recent gaming studies in Finland, which have also revealed that the popularity of mobile gaming continues to grow, surpassing PC and console gaming (Kinnunen et al. 2020). Furthermore, recent Finnish findings revealed that almost half (44.8%) of youth aged 10 to 19 years engage in gaming on a daily basis, with most (43%) increasingly playing games on smartphones.

In the present study, PC gaming was significantly related to insufficient MVPA. Previous studies have argued that there is a specific sub-group of gamers who favor "massive multiplayer online role playing games" (MMORPG) games, which usually require substantially longer sessions from players (Rehbein et al. 2010; Elliott et al. 2012; Thorne et al. 2014). Consequently, a study by Ballard et al. (2009) reported that both the duration of one gaming session and playing games online were negatively related to the duration of exercise. As PCs usually enable higher computing power, sophisticated game types (such as strategy, FPS, and MOBA) are often played on PCs. Computer gaming also enables the simultaneous execution of multiple tasks (gaming, social media use, and schoolwork, among others), which may require far more time than gaming on a console. Therefore, it can be argued that gaming with a computer – relative to other forms of gaming – can increase the amount of time displaced for PA and MVPA.

Our findings agree with what was reported in a previous study, i.e., participants who played sports and racing games typically spend less time on video games than those who prefer other game genres (Rehbein et al. 2010). The findings of the present study also show that playing sports video games is significantly inversely associated with insufficient MVPA, which supports previous longitudinal findings that this genre may be related with real-life sport involvement (Adachi and Willoughby 2015; Adachi and Willoughby 2016). Nevertheless, more research is needed to reliably demonstrate whether certain genres of games are associated with physical inactivity.

Limitations

This study has some limitations. First, the information concerning PA and digital gaming was derived from

self-reported questionnaires, which are potentially subject to response bias (Carson et al. 2016). The questionnaire used in this study has previously shown some limitations in terms of reliability, with respondents generally overestimating PA (Hagstromer et al. 2010) and underestimating their sedentary lifestyle (Shephard 2003). Second, total recreational screen-time was not assessed; this hampered the reliable evaluation of sedentary behavior and any related associations. Third, the present study applied a cross-sectional approach; thus, the direction of causality cannot be determined. For this reason, longitudinal studies that include precise evaluations of screen-based sedentary behavior are needed in the future. For example, comprehensive in-game behavioral data from players could provide new insight into specific relationships. Furthermore, it is important to note that the present findings are based on a convenience sample of youth.

Conclusion

Our findings suggest that certain digital gaming characteristics are related to the recreational physical activity habits of emerging adults. The current study revealed that spending more time on digital gaming is not significantly associated with lower levels of PA. However, male gender and online-based (e.g., strategy, FPS, and MOBA) PC gaming demonstrated positive associations with decreased PA; on the other hand, primarily playing sports video games was inversely associated with insufficient levels of PA. Future research should find objective ways to measure both digital gaming and PA, as there is a high degree of variation in how complex and multidimensional behaviors are assessed. The findings of the present study provide important insight that could be used to develop interventions that aim to promote physical activity among youth. Policies that focus on promoting PA, controlling sedentary behavior, and boosting healthy eating are one of the best ways to improve and maintain the overall health and well-being of the population.

Authors' contributions Mikko Salmensalo, Conceptualization, Formal analysis, Writing – original draft.

Heidi Ruotsalainen, Conceptualization, Data curation, Methodology, Supervision, Writing – review & editing.

Krista Hylkilä, Writing – review & editing.

Maria Kääriäinen, Conceptualization, Data curation, Project administration, Supervision, Writing – review & editing.

Jenni Konttila, Writing – review & editing.

Merja Männistö, Writing – review & editing.

Niko Männikkö, Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Funding Open Access funding provided by University of Oulu including Oulu University Hospital. No financial support was received for this study.

Data availability The data generated and/or analyzed during the current study are not publicly available due legal/ethical reasons but are available from the corresponding author on reasonable request.

Declarations

Ethics approval Ethical approval by an Institutional Review Board of Ethical Committee was not required in the present study following the guidelines of the Finnish National Board on Research Integrity.[1] and national legislation (the Finnish Constitution 1999/731; Medical Research Act 488/1999).

Research involving human participants All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional and state research committee as well as the 1964 Helsinki declaration and its later amendments.

Consent to participate Informed consent was obtained from all individual participants included in the study. Students agreed to participate in the study through the informational page.

Conflict of interest The authors declare no conflict of interest.

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