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## Associations Between Gaming and Physical Activity Among Finnish Adolescents During and After the Spring 2020 COVID-19 Lockdown

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### Abstract

**Aims:** To examine the evolving trends of video game play, such as esports, between spring (COVID-19 lockdown) and autumn 2020 among Finnish high-school students. Moreover, to examine the associations between video gaming and physical activity (PA) behaviours.

**Methods and Results:** Data from online self-report surveys; a Finnish late-adolescent physical activity (LAPA) study during spring ( $n = 2459$ ) and autumn ( $n = 4781$ ) 2020 were used to address the aims of the study. Descriptive statistics to compare the change between spring and autumn 2020 were used. Multinomial logistic regression analyses were stratified by data collection, with PA as the outcome after controlling for gender, age, disability, and place of residence. There were increases between spring and autumn 2020 in video gaming behaviours among all genres covered in the LAPA study. Esports play during the autumn was negatively associated with daily PA (OR = 0.65, CI = 0.44 – 0.95) but not during the spring. On the other hand, playing sports video games was positively associated with PA at least five days a week in both the spring (OR = 1.86, CI = 1.26 – 2.74) and autumn (OR = 2.14, CI = 1.65 – 2.77) time periods.

**Conclusions:** There were increases in gaming behaviour between spring (the COVID-19 lockdown) and autumn 2020 among Finnish high school students, especially among esports players. There were negative associations between playing esports and daily PA. Since daily PA is the Finnish national recommendation, esports players could be a target group for promoting PA behaviours.

**Keywords:** Behaviour Change; Cross-sectional, Finland, Sport Video Games, Esports

### Highlights

- There was an increase in all forms of video gaming behaviour between spring (the COVID-19 lockdown) and autumn 2020, with large increases in esports playing.
- Esports playing was not associated with levels of physical activity during the spring data collection, although playing sports video games was positively associated with physical activity levels at both time points.

- Despite physical activity levels hardly changing between spring and autumn, playing a lot of esports was negatively associated with daily physical activity during the autumn data collection.

## Introduction

Due to the COVID-19 pandemic, governments applied prolonged stay-at-home directions that disrupted people's everyday lives. From adolescents' perspectives, different social distancing restrictions led to, for instance, remote schooling and the cancellation of leisure time activities. Adolescence is a critical period for rapid social, physical, cognitive, and emotional development, with implications for health and well-being in later life (Azzopardi et al., 2019). Under the exceptional circumstances during COVID-19, interferences in adolescents' physical and social habits raised potential concerns. Children and adolescents were particularly vulnerable, compared to adults, due to their limited coping strategies, communication skills, and understanding of the event (Imran et al., 2020).

Overall, although restrictions varied from country to country, one evident change in people's daily habits and behaviour was increased video gaming time (Han et al., 2022). The increases in video gaming activity (GA) were more prominent for multiplayer games (Vuorre et al., 2021), including popular esports games. The increase in esports GA, especially during lockdown periods can be seen in monthly activity charts in games like *Counter-Strike: Global Offensive* (Steam Charts, 2022a), *League of Legends* (Petrosino et al., 2021), and *Rocket League* (Steam Charts, 2022b).

The world of video games offers a wide range of games that cater to the diverse preferences and motivations of different players. Different video games tend to appeal to different people (Peever et al., 2012), so sub-groups exist based on the types of games they play. Role playing games have a decades-long history that originates from tabletop games. They demonstrate a lot of story-like elements, allowing players through their characters to do whatever is possible in the shared imaginary world of the game (Hitchens & Drachen, 2008). In adventure games, a story is the driving force behind the gameplay and can have a quest-type structure that influences the player's progression in the game (Vara, 2009). With puzzle games, the central mechanism is problem solving. Typically, puzzle games have a linear design, starting with simple challenges; upon their completion, challenges become more complex (Linehan et al., 2014). Sports video games simulate a sport of some kind in which, usually, the player controls game avatars. It has been argued that most sports gamers identify themselves as sports fans, and this identity extends to other sports-related activities in addition to playing the sports video games (Stein et al., 2013). The main feature of strategy games is the complexity of decisions made by the player in a simulated universe. Strategy games often involve elements of tactical and strategic features to reach a long-term goal: for example, conquer a virtual world (Gabbiadini & Greitemeyer, 2017). As the name suggests, massive multiplayer online (MMO) games are played online by multiple players, often cooperatively but on occasion competitively, in a range of communal gameplay activities (Corliss, 2011). Players can interact, form friendships, work together, and deceive each other, just like in real life (Chen et al., 2020). A widely accepted definition of esports across disciplines is competitive gaming (Reitman et al., 2020). In the context of this study, esports games can be considered an intersecting genre, as they are not largely defined by the characteristics of the games but include the most popular games played competitively.

In Finland, where this study was conducted, the effect of the pandemic on GA has been reported as well. Digital gaming, especially among children and adolescents, is one of the most popular activities, as almost four out of five (79%) Finnish 10–19-year-olds play digital games weekly or more often, 45% play daily, and only 1% of this age group never play any form of digital games (Kinnunen et al., 2020). These rates of participation increased during the lockdowns in 2020 compared to the previous report from 2018 (Kinnunen et al., 2018). Reasons for these changes resulting from the COVID-19 pandemic included the relaxing effect of

gaming, helping one cope with stress or was a part of daily routines (Karhulahti et al., 2022). Adolescents' involvement in competitive esports has increased, too. Among active adolescent gamers, 8% play esports games competitively, and 26% watch competitive esports-related broadcasts or recordings (Kinnunen et al., 2020).

These findings are a consequence of the circumstances of the public health emergency having turned the entire world on its head. For instance, while most major sports competitions were cancelled or postponed (Nauright et al., 2020), the esports scene was able to move its larger events online, resulting in minimal changes for most viewers (Fnatic, 2020). GA and online esports competition thrived professionally during the pandemic (Ortiz et al., 2020).

At the individual level, the perceived well-being of some players improved (Barr & Copeland-Stewart, 2021); the overall effects, however, appear to be heterogenous due to the great diversity of gaming contexts and habits (Karhulahti et al. 2022). According to some reports, GA helped individuals cope with social distancing (Meriläinen, 2022) by mitigating their stress, anxiety, depression, and loneliness (Pallavicini et al., 2022). For some adolescents, participating in GA was a way to maintain a social life and provided a social space for sustaining friendships and coping with boredom (Bengtsson et al., 2021). On the other hand, along with increased engagement with GA and esports, decreases tended to occur in physical activity and sleep time, which is potentially related to adolescents' post-pandemic increase in obesity rates (Yang et al., 2020).

Given the increase in GA with substantial environmental and social changes due to the restrictions, one might assume that everyday activities, such as PA, would have been affected. In that respect, expanding evidence suggests that COVID-19-related lockdowns decreased children and adolescents' PA and increased sedentary behaviour around the world (Stockwell et al., 2021). Researchers have shown that PA, defined as any bodily movement that requires energy expenditure, is associated with numerous positive health outcomes (Janssen & LeBlanc, 2010). On the other hand, sedentary behaviour is defined as any waking behaviour by an energy expenditure of less than 1.5 metabolic equivalent of task (MET), is associated with several negative health outcomes (Carson et al., 2016). Researchers have also called the global inactivity problem itself a pandemic (Kohl et al., 2013), with less than 20% of children and adolescents around the world meeting international PA guidelines (Guthold et al., 2020). Furthermore, rates of adolescents who are sufficiently active are typically at their lowest levels during the high-school years (Woods et al., 2021).

### ***Physical activity and gaming activity***

There have been at least some efforts to investigate the relationship between PA and GA in adolescents during COVID-19. Some studies regarding specific gaming genres, such as active video games (Santos et al., 2021) and augmented reality games (Ellis et al., 2020), have reported contradictory results in the expected GA and PA relationship during the pandemic, but the popularity of these games is very limited (Limelight Networks & AnimationXpress, 2021). In addition, there is some evidence that esports players, even at the amateur level, can spend approximately 40% more energy while playing stationary, and thus concurrently exceed the SB energy expenditure limit of 1.5 METs (Kocak, 2021). The result is at least somewhat encouraging from a health perspective, as esports players sit in front of a screen between three and 10 hours per day practicing (DiFrancisco-Donoghue et al., 2019) and are typically less physically active than the global general population (Trotter et al., 2020). Among elite esports players, however, the likelihood of meeting recommended PA levels is high (Kari et al., 2018; Giakoni-Ramírez et al., 2022). Professional players' exercise routines could be a good catalyst to promote PA among amateur esports players and could simultaneously enhance their gaming performance as well (de Las Heras et al., 2020).

A more general overview of the relationship between PA and GA in adolescents during COVID-19 was conducted in Germany and Norway. In the German study, young adults reported on their social-media use, digital-media use, and PA (Helbach & Stahlmann, 2021). Only some of the respondents, however, could be categorized as adolescents, and computer usage was not differentiated between gaming and non-gaming usage. A potential recall bias and bias relating to seasonal aspects of PA were noted by the authors as well. In the Norwegian study, a two-wave longitudinal cohort study was performed during the pandemic to assess PA and GA (Haug, et al., 2022). As a result, increased gaming among many adolescents and a relationship with physical inactivity were observed. The Norwegian publication appears to be one of few studies, if not the only extant study, seeking the associations between adolescents GA and PA during the COVID-19 pandemic. Neither of the studies, however, provided detailed information on the connection between different game genres and types of gaming, such as esports, and PA.

The aim of this study was to investigate the changes in video gaming, such as esports activity, during (spring) and after (autumn) the 2020 spring COVID-19 lockdown among Finnish late adolescents. Further aims included the investigation of the associations between PA and video game genres, including esports. In particular, the moderate effect of playing esports on the PA was investigated to understand the dose effect of esports play on individuals' PA levels in the comparative context of other GA types.

## **Methodology**

### ***Sample***

Schools were recruited through a probability proportion to size sampling frame, where region (capital, south, central, and north) was the sampling frame cluster. The recruitment manager requested one class per school from the schools. Recruited schools arranged a class time for the randomly selected class to complete an electronic survey.

In Finland, after completing basic education at the age of 15 years, students have the choice to go to high school or vocational colleges. Few choose the dual route of attending both high school and vocational college. The setting and daily activities differ vastly between high school and vocational schools; hence, for this study, we focus solely on the data from high-school students.

In Finland, individuals over the age of 15 are allowed to give their assent to participate in a study without parental consent. Completion of the study was carried out voluntarily, with no penalty for not completing the survey, and the individual could stop the survey at any point. All incomplete responses were excluded from the data file.

### ***Measures and Variables***

The survey instruments were part of a larger study that takes around 40 minutes to complete. All items were self-reported and grouped into question batteries.

PA was measured through a single item that included a definition of moderate to vigorous physical activity (MVPA); the survey then proceeded to ask the individual to specify the number of days in the last week that they had completed MVPA for at least 60 minutes. Such a question covers the areas of frequency (number of times in a week), intensity (including only moderate to vigorous physical activity), and time (at least 60 minutes) and has been recommended for surveillance use (Biddle et al., 2012). This self-report item has acceptable

test-retest reliability among 15-year-olds (Ng et al., 2019) and has moderate correlations with hip-worn tri-axial accelerometers (Hardy, et al., 2015). For the purpose of the analyses, the response options were grouped into four categories: 0–2 days (inactive), 3–4 days (somewhat active), 5–6 days (active), and 7 days (daily active). The breakdown into four groups was carried out to improve the understanding of PA behaviours of those who were not daily active (Mehtälä et al., 2020; Woods et al., 2021).

The GA battery included several items on gaming behaviour in a logic-wise approach. In this study, the following genres were examined: role-playing games, adventure games, puzzle games, sports video games, strategy games, MMO, and esports games. The first item filtered individuals down to those for further analyses with the question, “Do you play video games (mobile, console, computer, etc)?”. Individuals who responded “no” were not analysed further. Individuals who responded “yes” were introduced to items about their video gaming behaviour. The duration of gaming was broken down by the following genres, with examples in the question: i. action and role-playing games (e.g., *Red Dead Redemption*, *Zelda*, *Grand Theft Auto*, *Skyrim*, *Mass Effect*), ii. adventure games and interactive movies (e.g., *Monkey Island*, *Heavy Rain*, *Walking Dead*, *To The Moon*, *Doki Doki Literature Club*), iii. puzzle games (e.g., *Angry Birds*, *Bejeweled*, *Candy Crush Saga*, *Puzzle & Dragons*, *Solitaire*), iv. sports games (*Grand Turismo*, *FIFA*, *NHL*, *Wii Sports*, *Football Manager*), v. strategy and building games (*Civilization*, *Cities Skylines*, *Minecraft*, *Clash of Clans*, *Europa Universalis*) vi. MMOs (e.g., *World of Warcraft*, *Guild Wars 2*, *Neverwinter*, *Elder Scrolls Online*, *Runescape*), and vii) esports games (*Fortnite*, *League of Legends*, *Counter Strike*, *Clash Royale*, *Overwatch*). Response categories were given on a five-point Likert scale from “Never” to “Quite a lot”. For the purpose of the binary statistical analyses, the responses were regrouped into “Quite a lot” and “A lot” (1) and “Never,” “A little,” and “Somewhat” (0).

Covariates included age, gender, disability, family affluence, and place of residence. Age was determined from a calculation of month and year of birth at the time of data collection. Gender was a single item on how they identified themselves, with options of male, female, and other. Disabilities were measured through the self-report version of the Washington Group/UNICEF Child Functioning Module (Ng et al., 2019). There were 11 items based on 11 core functions for functioning that were grouped into communication, active daily living, cognitive, and social-behavioural functional difficulties. For the analyses, individuals who reported that they had at least a lot of difficulties in at least one function were identified as having disabilities. Family affluence was a composite score of family material wealth as a proxy measure for socioeconomic status (Hartley et al., 2015). Place of residence was determined by responses to a question about where they lived, with responses grouped into either “urban” or “rural.”

**Data Analysis.** Descriptive statistics were performed on the entire sample stratified by survey collection point, as well as pooled with both samples combined. Multinomial logistic regression analyses were carried out with gaming genres as predictors for increases in MVPA, with inactive (0–2 days) and never, a little, and somewhat gaming for each genre as the reference categories. The analyses were adjusted for age, gender, disability, and family affluence for data in the spring (lockdown) and autumn 2020 data sets. All statistics were carried out on Jamovi desktop version 2.2.5 software as a graphic user interface for R. The multinomial logistic regression model used the *nnet* package.

## Results

### Descriptive Statistics

The sample from the autumn data collection ( $n = 4781$ ) was almost double the size of that from the spring ( $n = 2459$ ), and there were also differences in some of the demographics of the samples (Table 1). For example, there were more female respondents in spring (64%) than autumn (59%), more 3rd year students in the autumn (16%) than in the spring (1%), and more urban respondents in the spring (68%) than in the autumn (60%). Furthermore, there was a 1% increase in late adolescents with disabilities in the autumn (17%) than in the spring (16%).

Table 1. LAPA spring and autumn 2020 participant characteristics in percentages

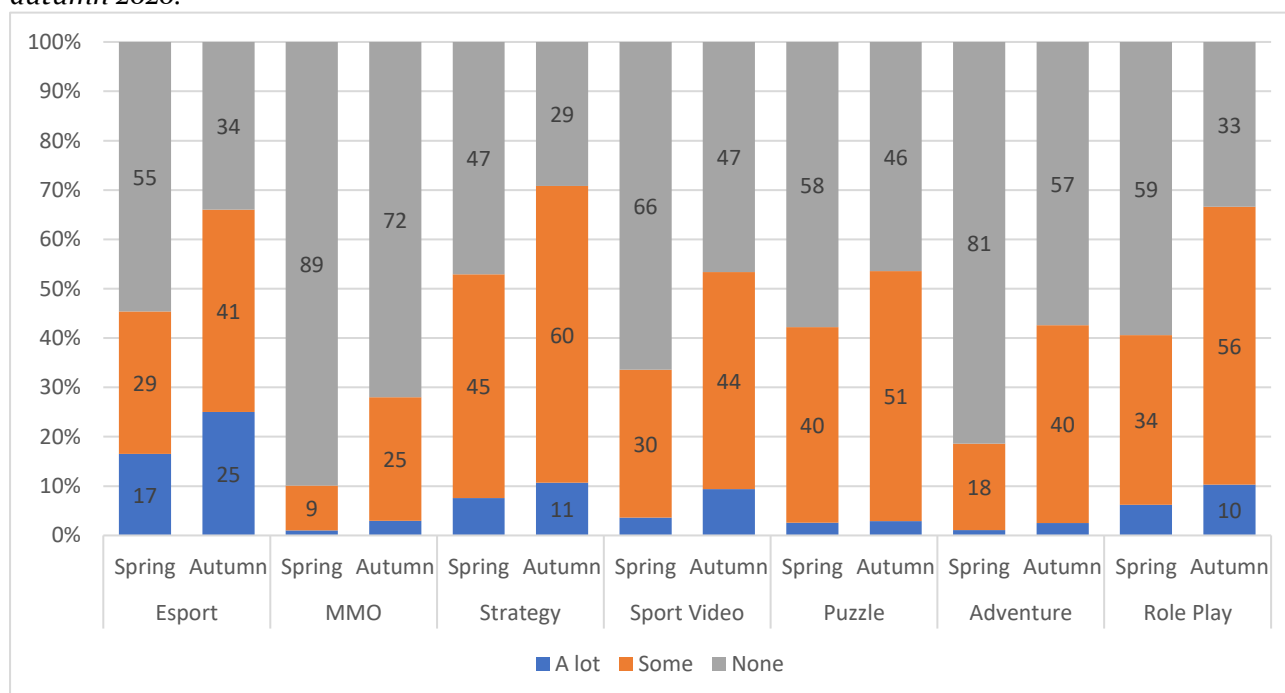
	Survey Time Point			p-value ( $\chi^2$ )
	Total	Spring	Autumn	
Total (n)	7240	2459	4781	
Gender	%	%	%	<.001
Male	39.1	35.8	40.8	
Female	60.3	63.6	58.5	
Other	0.6	0.5	0.7	
Age (Mean, SD)	17.14, 0.76	17.26, 0.65	17.07, 0.81	
Year of study	%	%	%	<.001
1st year	51.1	58.1	47.5	
2nd Year	37.7	40.5	36.3	
3rd year	10.8	1.1	15.8	
Missing	0.4	0.2	0.5	
Place of Dwelling	%	%	%	<.001
City, centre	15.1	17.5	13.8	
City, outside of centre	47.0	50.6	45.1	
Village centre	23.0	18.2	25.5	
Village outside of centre	14.9	13.7	15.6	
Person with Disabilities	%	%	%	0.048
Without disabilities	83.3	84.5	82.7	
With disabilities	16.7	15.5	17.3	
Sensory difficulties	1.9	2.7	1.5	<.001
Physical difficulties	0.4	0.5	0.4	0.672
Cognitive difficulties	8.0	7.6	8.2	0.341
Behavioural difficulties	9.5	9.4	9.5	0.906
Days of 60min/day MVPA	%	%	%	0.187
0-2 days	22.7	23.1	22.5	
3-4 days	34.0	35.2	33.3	
5-6 days	30.8	29.9	31.2	
7 days	12.6	11.8	13.0	
Days of VPA/week	%	%	%	0.26
Less than 3 times	45.0	44.0	45.4	
3 times or more	55.0	56.0	54.6	
Active Sport Club Member	%	%	%	0.005
Not member or active	67.7	65.6	68.8	
Active member	32.3	34.4	31.2	
Gaming activity	%	%	%	<.001
No, I do not game	42.9	29.7	47.6	
Yes, I game	57.1	70.3	52.4	

Roleplaying none	41.9	59.4	33.4	<.001
Adventure games none	65.3	81.4	57.4	<.001
Puzzle games none	50.1	57.8	46.4	<.001
Sport video games none	53.3	66.4	46.6	<.001
Strategy games none	35.1	47.1	29.2	<.001
MMO none	77.8	89.4	72.1	<.001
Esports none	41.0	54.6	33.9	<.001

Note. MMO: massive multiplayer online.

There was an increase in GA in all genres between spring and autumn 2020 (Figure 1). Approximately one in six late adolescents played esports games in spring 2020, with over half playing none. In the autumn, this frequency was reduced to one in three adolescents who reported playing no esports games in the autumn and over one quarter who reported that they played esports games a lot. Even the uptake of MMO and adventure games increased remarkably in the autumn.

Figure 1. Changes in the frequency of playing games (%) between spring (COVID lockdown) and autumn 2020.



Gender, age, and place of residence were not statistically associated with increased days of MVPA, although the statistically significant association with disability was negative, as days of MVPA increased during the spring (lockdown) time. In the autumn, age, gender, disability, and place of residence were associated with increased levels of MVPA compared to 0–2 days of MVPA (Table 2).



Table 2. Background variable odds ratios and 95% confidence intervals for increased physical activity during spring (lockdown) and autumn 2022

	0-2 Days		3-4 Days MVPA			5 - 6 days MVPA			Daily (7 days) MVPA				
		p	OR	LCI	UCI	p	OR	LCI	UCI	p	OR	LCI	UCI
<b>Spring</b>													
Increasing Age	REF	.157	0.84	0.66	1.07	.035	0.75	0.58	0.98	.067	0.72	0.50	1.02
Gender													
Female	REF												
Male		.378	0.87	0.63	1.19	.37	1.17	0.83	1.64	.448	1.20	0.76	1.89
Disability													
No Disabilities	REF												
Disabilities		<.001	0.43	0.29	0.64	<.001	0.39	0.26	0.62	.004	0.39	0.20	0.73
Residence													
Village Outskirts	REF												
Village Centre		.803	1.07	0.62	1.85	.325	1.37	0.73	2.57	.350	1.45	0.66	3.18
City Outskirts		.606	1.13	0.70	1.83	.033	1.82	1.05	3.15	0.93	1.03	0.50	2.11
City Centre		.848	1.06	0.60	1.87	.257	1.46	0.76	2.79	0.58	1.26	0.55	2.90
<b>Autumn</b>													
Increasing Age	REF	<.001	0.74	0.65	0.85	<.001	0.76	0.66	0.88	<.001	0.69	0.57	0.84
Gender													
Female	REF												
Male		<.001	1.49	1.18	1.89	<.001	1.96	1.53	2.53	<.001	3.04	2.14	4.33
Disability													
No Disabilities	REF												
Disabilities		<.001	0.59	0.44	0.78	<.001	0.54	0.40	0.74	<.001	0.43	0.28	0.67
Residence													
Village Outskirts	REF												
Village Centre		.316	0.84	0.60	1.18	0.160	1.32	0.89	1.94	.802	1.07	0.65	1.76
City Outskirts		.621	1.08	0.79	1.50	<.001	1.86	1.94	2.67	.037	1.63	1.03	2.57
City Centre		.077	1.47	0.96	2.24	0.005	1.96	1.22	3.14	.050	1.81	1.00	3.27

REF = Reference categories in the multinomial logistic regression

### Associations among Esports, Gaming, and Physical Activity

After adjusting for gender, age, disability, and place of residence (Figures 2 and 3), adolescents who reported playing roleplay games were less likely to report 3–4 days of MVPA (OR = 0.9, CI = 0.4 – 0.6) or daily MVPA (OR = 0.8, CI = 0.3 – 0.5) compared to adolescents who reported playing no roleplay games and being physically inactive. Another gaming genre with a pattern similar to that of roleplay games was strategy games. In other words, not playing roleplay games was associated with increased levels of PA during the spring (lockdown). There was also a negative association between playing esports and daily MVPA (OR = 0.65, CI = 0.45 – 0.95) in the autumn sample, but it was not statistically significant with any other amount of MVPA or in the spring sample.

Figure 2. Associations between video games and increasing physical activity (Reference category: 0–2 days) odds ratios and 95% confidence intervals during spring (COVID-19 lockdown) 2022. Blank boxes represent statistically significant associations. Upper confidence interval for “sport video games” was truncated and is 6.2. M.Multiplayer Online: massive multiplayer online.

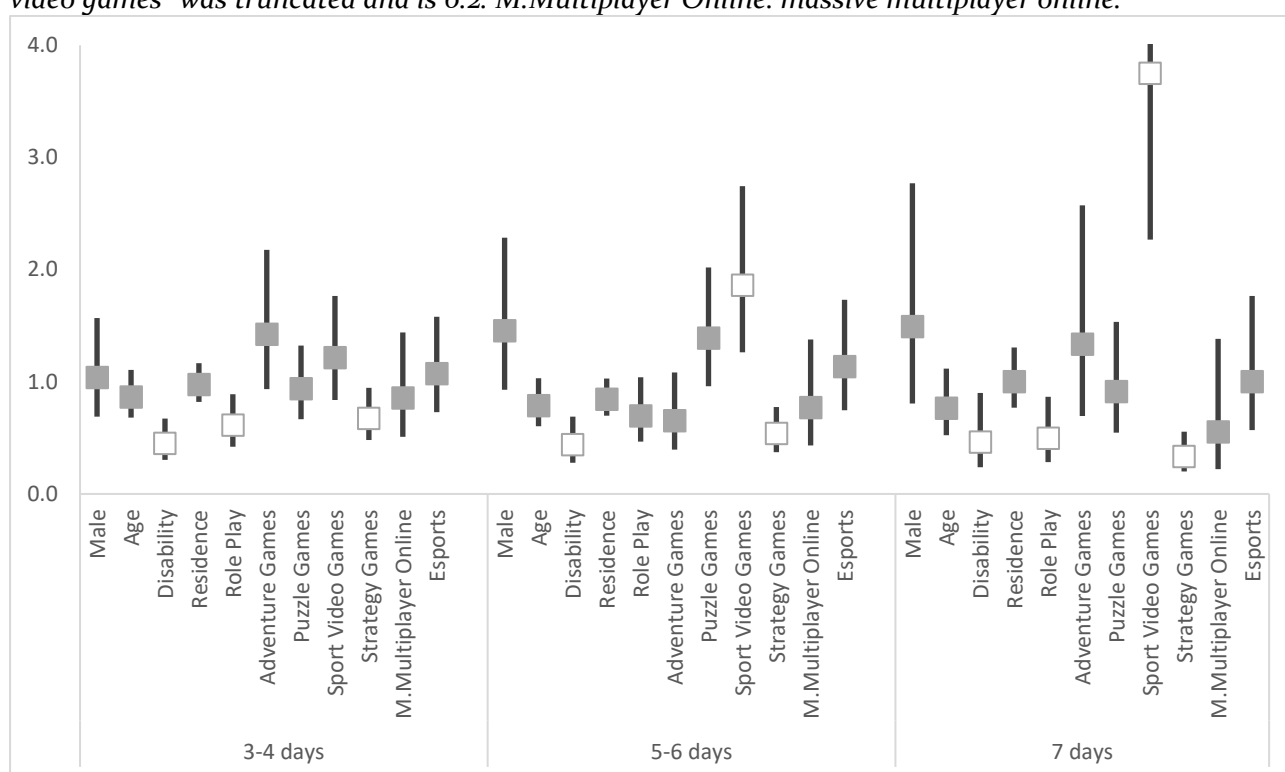
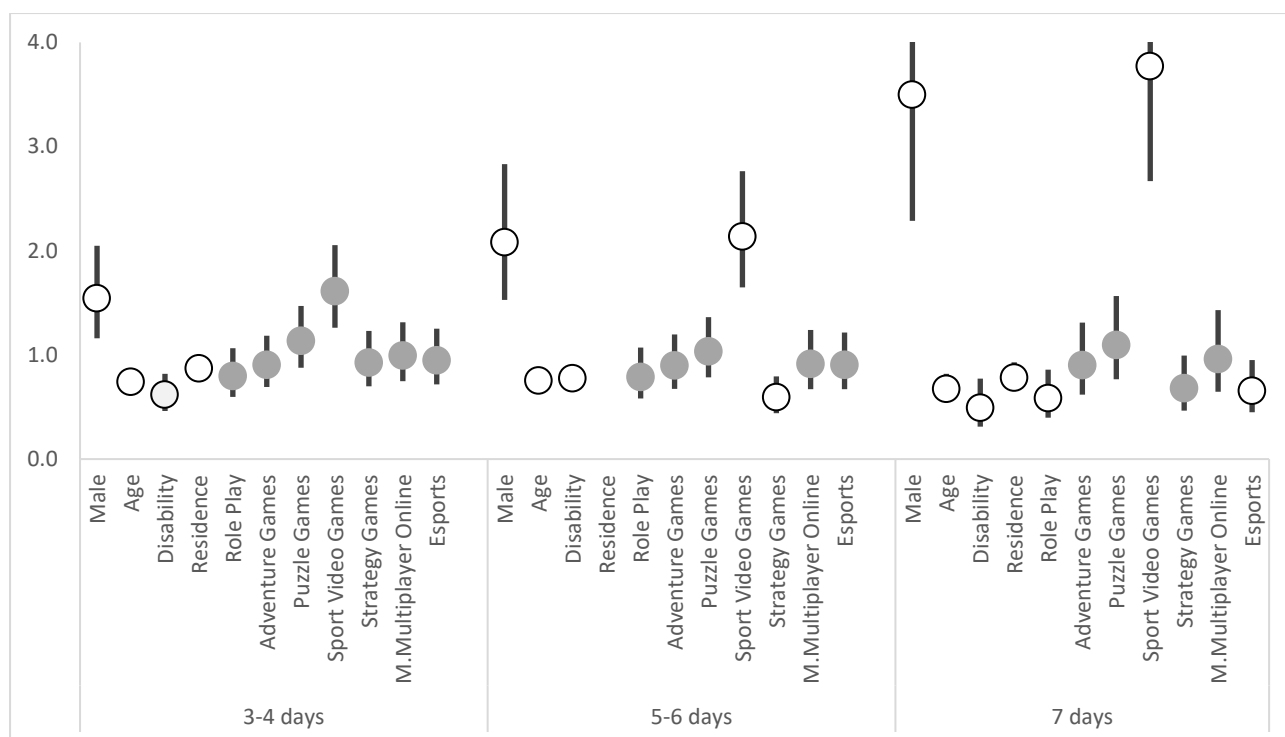


Figure 3. Associations between video games and increasing physical activity (Reference category: 0–2 days) odds ratios and 95% confidence intervals during autumn 2022. Blank boxes represent statistically significant associations. Upper confidence interval for “sport video games” is 5.3 and for male is 5.35 but cannot be viewed, as they are truncated in the image. M.Multiplayer Online: massive multiplayer online.



There were also statistically significant associations between playing sports video games and participating in more than five days of MVPA during the spring (lockdown). The associations remained the same in the autumn, with individuals who played sports video games being three times more likely to report daily rather than 0–2 days MVPA. In the autumn, males were over three times more likely to report daily MVPA than females. Gaming did not change the direction of associations from the model with only background variables.

## Discussion

In this study, we investigated the PA and esports GA behaviours of Finnish high-school students from two large nationally representative studies in 2020. The repeated cross-sectional studies took place during the COVID-19 lockdown (spring) and afterwards (autumn), and, although PA levels did not differ statistically, there were increases in the majority of gaming activity for all included gaming genres among Finnish high-school students.

For general GA, two genres of gaming were negatively associated with higher amounts of PA during lockdown. A possible explanation for strategy games and roleplaying having joint negative association with PA is that respondents were allowed to select multiple GA options, therefore many esports MMO players likely also selected “strategy” or “roleplaying” as their genre. The former historically derives from real-time strategy play, and involves character levelling, as do roleplaying games. We tested this hypothesis with the data and found that a third of strategy and a quarter of roleplaying game players played a lot of esports as well. Overall, both strategy and roleplaying games tend to be time-consuming and may thus make it less possible for individuals to spend sufficient time being physically active. Given that playing strategy or roleplaying games had a lower odds ratio with participating in daily MVPA, more attention is needed to promote PA behaviours among players who identify as such types of players. More research is also needed to investigate health-related behaviours for multiple gaming genre profiles.

Another finding from this study was the negative association between esports gaming and daily MVPA in the autumn. The number of active esports players halved between the spring

lockdown and autumn. In the spring, the association between esports and PA was not statistically significant, yet, in the autumn, the negative association with daily MVPA was statistically significant. One possible explanation for the above is that strategy and roleplaying gamers, whose habits did not involve daily PA in the spring either, moved to play esports games due to the reduced offline social opportunities in the pandemic (Karhulahti et al., 2022). Another possible explanation is that the lockdown may have moved esports players' active social networks into virtual spaces, which again contributed to difficulties related to re-engaging in daily PA. Either way, more research is needed to assess whether similar patterns persist in the post-pandemic years and across different cultures. If it turns out that adolescents who actively engage in esports are less likely to meet daily PA recommendations (Marker et al., 2022), further promotion of healthy physical habits in esports communities and environments should be considered. For instance, esports developers could use design features, such as those of mobile augmented reality games, to reward their players for daily active outdoor time.

On the other hand, positive associations were found between players of sports video games and MVPA at least five days a week. Similar results have been found in earlier studies regarding children and adolescents (Adachi & Willoughby, 2015; Ng et al., 2022). The expanding evidence supports a theoretical explanation that the increase in PA could be based on the connection between sports video games as part of a physical activity relationship (PAR). According to the PAR (Koski, 2008), personal physical activity and other habits related to it, such as sports spectating, form a social world that is a cultural part of life. In this context, sports video games can be considered a modern way of maintaining one's relationship with the social world of PA and sports. The view that playing sports video games can contribute to a better understanding of a sport (Kayali, 2013) because sports video game players are situating and understanding their sports video game play as part of a broader sports context (Stein et al., 2013) is in line with the PAR theory. To explore these relationships further, more studies are needed. For the sake of promoting PA, it would be necessary to investigate whether sports video game activity increases perceptions of the importance of PA or whether sports video game activity is a benefit of existing PA habits and the importance of PA. Furthermore, to acquire more insight into this topic, it would be fruitful to study side-by-side perceptions of PA and sports video games from the individuals who find both activities important (Pereira et al., 2021).

From the results of the study, MVPA was similar during the spring among different gender groups, ages, and place of residence. Much research has indicated lower levels of PA among females compared to males, as well as a decrease with age (Kalman, et al., 2015). Still, more recent research on late adolescents demonstrates that gender differences were only significant for daily MVPA but not for the lower levels of PA frequency (Ng et al., 2019). There have been worldwide efforts to promote PA among females through the inclusion of activities other than traditional sports games in the physical education (PE) curriculum (Owen et al., 2017). Moreover, in Finland, there are many opportunities to be physically active by accessing urban walking areas or being close to nature (Pietilä et al., 2015). Despite these infrastructure advantages, the differences in PA between high-school males and females reappeared in autumn 2020. Activities during lockdown may have reduced the PA routines of individuals as opportunities were made unavailable (Ng, Cooper et al., 2021). During adolescence, peer relationships become more complex and important (Brown & Larson, 2009), leading to the importance of programmes that target peer-led strategies (McHale et al., 2022). Furthermore, as autumn was the first time that people had the opportunity to meet with each other since the lockdown, gendered differences appeared in the mechanisms with which to cope with the pandemic, such as loneliness, support, and school work (Ellis et al., 2020).

The data in the autumn also saw an increase in video gaming behaviours, but, overall, PA remained relatively the same between lockdown and afterwards. Therefore, the idea presented in the previous literature—that one behaviour was swapped (gaming) for another behaviour (PA)—was not fully supported. This may have been due to the amount of time measured in PA, which was measured in the survey by the amount of change in 60 minutes of MVPA per day. With approximately 16 hours of waking time and six hours of school time daily, one hour of PA represents at least one-tenth of their remaining daily time (assuming that they have not done any PA during school time). Despite the instrument's lack of sensitivity to measure PA, changes to device-based measures of PA remained relatively the same between spring and autumn 2020 (Kokko et al., 2020), reinforcing the lack of change, on average, in PA between spring and autumn 2020, whereas, with gaming activities, playing games takes place only during leisure time. This could be a reason that increased gaming was noticed between lockdown and afterwards but PA levels did not significantly change.

### **Considerations**

This repeated cross-sectional study has some limitations to be considered when interpreting the results. The cohorts were randomly selected from each time point; hence, no longitudinal associations can be made at the individual level. Still, due to the national representative sampling procedures, we did not measure repeated measures at individual levels but tested for differences from the samples based on a random selection of individuals. Furthermore, a limitation of the study is due to the nature of the questions; we could not measure perceived changes in individuals because of restrictions due to COVID-19, as there might have been seasonal reasons for why gaming increased. As the cohorts were the same age, we noticed a shift in age from the generations from the academic year, and it is unknown whether the one academic year difference may have also led to the changes we noticed in the study. Without national cohort studies, it is difficult to assess whether this limitation is a strong factor in altering the interpretation of the results from the study. There were different survey administration procedures from the lockdown to the autumn. This may have left a distorted distribution from spring, as fewer participants completed the survey than intended due to the differences in restrictions across Finland. Despite this, there were still over 2,000 respondents, and a sufficient number of responses was reached to account for design effects. Finally, the basis of the results from the study was the set of self-report items. There may be some reporting biases to behavioural questions. Although the PA items have had psychometric properties tested since their inception in 2001, further studies are needed to report the psychometric properties of the video gaming behaviour items, which were conceived only recently.

### **Conclusions**

Increases in the GA of high school students took place between the spring and autumn of 2020. This was at a time when there were restrictions due to the COVID-19 pandemic prior to returning to a new normal. This new normal included at least a quarter of high school students who reported active sports play, whereas, at the beginning of the pandemic, fewer than one in six high school students played esports actively. Furthermore, during lockdown, esports play was not associated with PA, but, by the time of the autumn data collection, playing esports was negatively associated with participating in daily MVPA. This has implications regarding the need for adolescents to participate in daily MVPA, at least under the Finnish national PA recommendations. Further studies are needed to investigate the relationships between esports play and PA.

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