Research Topics

New trends in esports and gaming: analyzing the impact of esports and video games on body composition, psychological state and health of gamers/players

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Editorial: New trends in esports and gaming: analyzing the impact of esports and video games on body composition, psychological state and health of gamers/players

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KEYWORDS
esports, videogames, health, psychology, body composition, physical activity

Editorial on the Research Topic
New trends in esports and gaming: analyzing the impact of esports and video games on body composition, psychological state and health of gamers/players

In this special issue, we have collected eight articles that provide insight into video games and esports from a healthy perspective for gamers. Esports have developed considerably and rapidly in many areas over the last decade. The majority of this development has been at the competitive level, with competition attracting global interest. However, there are other areas of interest within video games and esports, such as health, psychology, and body composition, due to the fact that players spend many hours per day sitting down, and the psychological demands are very high. This special issue brings together studies that have addressed the health-related, rather than the performance-related, side of this field.

More specifically, the first three articles focused on the psychophysiological changes and alterations that occur while playing video games in an amateur and professional environment. Thus, the first article showed how the mood of the players, despite not affecting the subsequent performance of amateur players, did change when they played successive games depending on the outcome of the previous game. This is important since they tend to play several video games on the same day. The second article described how 3–4 h of competitive video gaming can negatively affect the perceived physical exertion and perceived physical fitness of esports athletes, which could affect their health. A passive break may provide short-term regeneration, but it would not allow for full recovery. On the other hand, breaks that incorporate physical activity could mitigate additional negative consequences of sedentary behavior. This makes physical exercise and body awareness a crucial part of esports training. The third article highlighted the physiological stress responses of players during gaming. Gaming sessions lead to physiological changes such as increased HR, blood pressure, energy expenditure, and reduced HR variability. However, game genre, game outcome and fitness level had no effect on the stress response.

The fourth and fifth articles discussed the potential benefits and problems of playing video games and esports. The fourth article examined the usefulness of video games, specifically virtual reality games, as a tool to combat the sedentary lifestyle that commonly characterizes esports players. It was shown how virtual reality appears to alter the perception of exertion during physical activity, specifically reducing the perception of real exertion. The importance of this lies in the fact that perceived exertion is negatively related to physical activity adherence, so virtual reality could facilitate adherence to physical activity, with the health benefits that this would bring. The fifth article focused on one of the main problems with esports players, which is the perception of esports players themselves by their parents. Lack of parental support puts children at greater risk of missing out on the positive outcomes associated with esports, making them more prone to possible negative consequences. Parental support is determined by attitudes and perceived behavioral control. Negative attitudes revolve around concerns for their children's health and academic success, while a lack of perceived behavioral control is based on unfamiliarity with esports. Increased positive exposure to esports could contribute to more positive parental attitudes and improved esports competence.

The sixth and seventh articles addressed the importance of the problematic use of video games for the health of players, along with a very specific aspect that can contribute to this problematic use, such as tilt, which can also have negative consequences for psychological health. Tilt is a specific gaming term associated with frustration, rage, and deterioration of gaming ability. Tilt is a phenomenon in which players are triggered by a person or event in the game that generates frustration and other negative emotions that, in turn, start to negatively impact decision-making and overall gameplay. The sixth article presented a new methodology for analyzing indicators of gaming behavior, with the aim of improving the diagnosis and understanding of internet gaming disorder. To do so, behavioral telemetry data was used to extract emotional states, providing a nuanced understanding of player behavior and emotion regulation. This tool can assist healthcare professionals in the diagnosis and monitoring of the therapeutic process, helping to solve some of the problems associated with traditional methods of assessing internet gaming disorder. In addition, the metrics and visualizations can also inform therapists about the problematic behaviors and gaming habits of each gamer, allowing for personalized treatment tailored to the individual and their needs. In light of the fact that tilt is one of the major problems affecting the psychological state of players, the authors of the seventh article presented a specific questionnaire to measure this variable. This questionnaire allowed for the conceptualization and quantification of the tilt phenomenon, laying the groundwork for exploring its intricate relationships with other variables of interest. Thus, tilt was defined as a construct characterized by a state of frustration that escalates into anger, resulting in diminished performance, attention, and recurrent negative thoughts about errors. This study also introduced a valuable and promising tool for future research efforts on the psychological experiences of esports players, transcending diverse cultural contexts.

Finally, the eighth article discussed the perception of the use of performance enhancers in the esports context. The competitive gaming community generally distinguishes between potential performance enhancers and is more concerned with "hard" drugs, pharmaceuticals, and brain stimulation interventions. Socially acceptable drugs and foods or food supplements appear to be more accepted. This affects the perception of fairness, which is key to the competition being seen as legitimate. If an institution (e.g., a tournament organizer) can ensure a competition that is widely perceived as fair, both the organizer and the outcome are more likely to be perceived as legitimate.

Author contributions

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The impact of videogames on the mood of amateur youth players during consecutive games

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Introduction: Esports have experienced tremendous growth in recent years. In the scientific field, previous research has shown the determining role of psychology in competitive performance, but little is known about the factors that may be more determinant. In addition, in the amateur field, where fun and enjoyment are the most important factors, it has been observed that players can see their psychological state altered due to different factors, but it is not known if the outcome of the game (win or lose) can be influential. For this reason, the aim of the present investigation was to analyze changes in players' mood between three consecutive games as a function of the outcome of each game.
Methods: A total of 14 amateur players participated in the research, all of them with previous experience and being regular League of Legends players. The participants completed the POMS questionnaire before the start of each game and the outcome of each game was recorded at the end.
Results: The results showed that no significant pre-game differences were found in any of the games, regardless of winning or losing. Significant differences were found in the pre-game mood between the first and second game, according to the outcome of the first game, and between the second and third game, according to the outcome of the second game. Between the first and second games, there was a significant increase in depression ($p = 0.038$) and anger ($p = 0.003$) when the first game was lost; and between the second and third games, there was a decrease in tension ($p = 0.003$) and anger ($p = 0.022$) when the second game was won. In addition, it should be noted that fatigue increased significantly after each game, regardless of the outcome, and with respect to the change in mood, this was more noticeable when the first game was lost and the second was won, as significant changes were observed in tension ($p = 0.028$), depression ($p = 0.030$) and anger ($p = 0.006$).
Conclusion: Pre-match mood does not influence post-match performance, but mood changes do occur between successive matches depending on the outcome of the match.

KEYWORDS
amateur, competitive games, esports, moods, psychology, social impact

1. Introduction

Esports, considered online video game competitions, have experienced a great growth and development in recent decades, leading to a massive increase in the number of players, spectators, and competitions worldwide (1–3). Competition is the most relevant element of Esports, with large economic investments being made and large-capacity facilities being used to host the events (4, 5). Due to its relevance, scientific research has been carried out in recent years to discover the most determinant variables in the performance of players during competitions (6–9), finding that environmental and personal variables are determinant. With respect to environmental variables, the light condition has been shown to be especially relevant, since the excessive screen time (exceeding 2 or 3 h of continuous play) to which esports players are subjected produces cognitive fatigue with pupillary constriction, decreasing cognitive performance (10), as well as eye fatigue (11). Regarding personal variables, sleep, nutrition, or psychological state, have been the most studied in the competition environment. Thus, previous research have shown that the performance of the players was diminished by sleep disturbances that affect the rest of the players, being furthermore likely to present sleep disorders due to the unique situations and conditions that characterize them (12) and that although esports players maintain a regular sleep pattern, most do not reach the minimum recommended sleep guidelines, with the best performing players being those who slept more, spent more time in deep sleep and less time in light sleep, showed lower non-REM respiration rates per minute, and earlier sleep offset (8); that nutrition and supplementation also seemed relevant, with performance being higher when nutrition was adequate, but more scientific evidence is needed to corroborate this (9); and that the psychological state of players seemed to influence competitive performance (6), and was also related to changes in certain physiological parameters such as heart rate (13).

So much so that the existing relationship between performance and different health parameters leads esports players to be at biopsychosocial risk, with their behavior being characterized by excessive caffeine supplementation, physiological arousal, injury, pain, stress, maladaptive coping, cognitive fatigue, game addiction or bullying, which affects their well-being (14). In addition to these unhealthy behaviors, there is another personal variable of great relevance, such as the excessive workload to which players are subjected (15). As esports are still in the development phase, not much information is available about workload control, subjecting players to long hours of training and competition (15). In this regard, heart rate, and more specifically heart rate variability, have started to be used in esports due to its potential to monitor player self-regulation (16). Thus, recent research has shown changes in HRV time-domain variables during games, as well as that the mean standard deviation of RR intervals was lower in the winning team than in the losing team, with some areas of analogous change in heart rate variability also existing in players at the end of matches (17); in addition, heart rate did not change when comparing games won and lost, but significant differences were found in heart rate according to the action performed, with those that directly involved the player and favored the team increasing hear rate the most (7). However, studies on workload, and more specifically on heart rate are limited in esports, and although they are used to understand the response to stress and the workload, there is a lack of theoretical evidence and methodological foundations to draw conclusions (16).

Of all esports, most of the previous research conducted so far has been developed on League of Legends (LOL), since it has a large number of professional and amateur players worldwide, being the most professionalized video game (18). LOL belongs to the multiplayer online battle arena (MOBA) genre, characterized by competitive, fast-paced games with teams generally consisting of five players trying to destroy the rival base (19). This form of gameplay gives rise to numerous interactions between the players in one's own team and those of the rival team (20, 21), which could lead to modifications in the psychological and physiological state of the players depending on the evolution of the game (6, 22). Not surprisingly, research conducted on professional LOL players has tried to establish the relationship between individual and collective performance in competition with psychological and technical-tactical performance variables (22, 23). More specifically, it has been found that in case of defeat in competition, changes in the mood of professional players occur, characterized by a significant decrease in vigor, and a significant increase in tension, depression, anger, and fatigue after the game (6). In addition, the effectiveness of psychological interventions to help players regulate their emotions and remain calm before and during games has been demonstrated (23, 24); as well as the influence of internal communication between players on the same team on individual and collective performance (25, 26).

However, although most of the research in LOL has analyzed psychological variables, scientific evidence is scarce. Thus it has been observed that mood changes during the game (6), but nothing is known about how mood behaves during successive games, nor whether the outcome of each game influences the mood with which the next game is approached. This is due to the fact that the majority of this research has analyzed what happens in LOL in isolation, considering the games as a single event (6). However, one of the great attractions of LOL for spectators are the final stages of the championship in which the teams face each other in a best of three or five consecutive games (Bo3 or Bo5), with the winner being the one that defeats the other team two or three times, respectively (27). Therefore, this is one of the main limitations observed in previous scientific literature investigating single games or regular leagues in which the games are separated by several days of rest (28).

This gap in the scientific literature on esports is important because it is known that in traditional sports, consecutive matches influence certain performance variables. Thus, it has been observed that in volleyball, consecutive matches affect heart rate variability (29); while in basketball, consecutive matches affect kinematic demands (relative distance, high intensity running, peak speed, deceleration) (30), as well as physical condition and psychological state (31). In esports, studies on the influence of congestion resulting from consecutive matches are practically nonexistent, but it has been observed that weeks with a higher number of games lead to poorer sleep quality for players (32). The absence of research on game congestion in esports becomes even more relevant when considering that in esports, the psychological component is more predominant than the physical one, and alterations of the psychological state are associated with disruptive behaviors during games (33, 34).

This type of behaviours are frequent in LOL games, as in 70% of games players are confronted with annoying situations, including disruptive behaviour towards their teammates or opponents (35, 36). This is especially important because, beyond the professional competitive environment, where players must perform to achieve the aims set by the team, in the amateur environment more and more players spend their free time playing LOL (37). This allows numerous players to share playful gaming experiences, with friends or strangers, becoming one of the main relevant form of digital entertainment (38–40). Therefore, the benefits of LOL as a video game could be undermined by a chain of negative outcomes in successive games, making players more vulnerable to manifest disruptive behaviors that would make the gaming experience negative.

Given that negative gaming experiences with other players keep players in a negative mood hours after the end of games (33, 41), are one of the main reasons to stop playing MOBAs (42, 43), and knowing that the mood prior to the game can predispose to the occurrence of this type of behaviors during games (33), it is necessary to know whether the results obtained in consecutive LOL games can attenuate or worsen the mood with which players face the next game. Even more so when considering that consecutive games of esports negatively affect the players' rest (32), so it could also affect mood. There is no previous research in this regard, and this study would make it possible to offer recommendations to players of this video game in particular, and esports in general, so that they are not so affected by the results of the games and do not stop playing it. For this reason, the aim of the present research was to analyze changes in the mood of amateur LOL players between three consecutive games as a function of the outcome of each game.

According to previous research, the following research hypothesis is proposed: H1) the mood of amateur LOL players will be affected by the outcome of each game, with the mood worsening to a greater extent with defeats occurring consecutively compared to defeats following a win.

2. Materials and methods

2.1. Design

The study design was cross-sectional, with non-probability convenience sampling. All the study participants signed the informed consent form prior to data collection, and were informed of the objectives of the study, as well as the processing of the data and the confidentiality of their treatment. Both the design and the development of the manuscript followed the STROBE statement (44), and the Institutional Ethical Committee reviewed and authorized the protocol designed for data collection, according to the Code from the World Medical Association (code: CE112002). The present research also follow the guidelines of the Helsinki declaration (to meet satisfactory ethical standards during scientific research).

2.2. Participants

The study sample size was calculated using Rstudio 3.15.0 (Rstudio Inc., USA). The significance level was set at $\alpha = 0.05$. The standard deviation (SD) was established based on previous studies that examined mood measures, tension (mean SD = 6.33), depression (mean SD = 10.78), anger (mean SD = 9.20), vigor (mean SD = 8.27), and fatigue (mean SD = 5.54) (6) in League of Legends games. Assuming an estimated error (d) of 3.31 for tension, 5.64 for depression, 4.82 for anger, 4.33 for vigor, and 2.90 for fatigue, the minimum sample needed for this study was 12 players.

The final sample consisted of 14 amateur League of Legends players (mean age: 22.36 ± 3.15; mean League of Legends experience: 5.14 ± 1.61 years) who voluntarily participated in the study. From each participant, three games were analyzed, so a total of 42 games were included in the analysis of the present research. The selection of the sample was carried out by non-probabilistic convenience sampling, selecting all possible subjects who had access and met the inclusion criteria: (1) have at least two years of experience in League of Legends; (2) be a regular player, referring to having played at least one game in the last week; (3) not being a professional player; and (4) and have one of the qualifying ranks (iron, bronze, silver, gold, platinum, diamond, master, grandmaster, or challenger) in competitive League of Legends games.

The small size of the final sample ($n = 14$) is due to the fact that most of the players contacted (initial $n = 63$) did not meet any of the inclusion criteria. More specifically, the players did not meet criteria 2 (be a regular player) and 4 (have one of the qualifying ranks). This is because previous research has shown that most esports players, and more specifically LOL players, are sporadic players, who play isolated games and can spend up to 100 days to return to the game (45). This made it difficult to include players, as many of the players initially contacted did not have a qualifying rank as they had not played games for months.

2.3. Instruments

For the League of Legends data collection, all the players used similar computers with the following characteristics: Asus Intel Core i7 8700 k 3.7 Ghz (Intel Corporation, United States), Venom N10 liquid cooling (Netway, Spain), Asus GeForce GTX 1060 6 GB DDRS graphics card (ASUSTeK Computer, Taiwan).

To obtain the psychological score, the abbreviated Spanish form of the Profile of Mood States (POMS) questionnaire was used (46, 47), which had an adequate internal consistency, as shown by the Cronbach's alpha values between 0.70 and 0.83 for the five dimensions analyzed (47). This questionnaire consists of 29 items that allow the evaluation of five mood-related factors; four negative (tension, depression, anger, and fatigue) and one positive (vigor), using a four-point Likert scale for its scoring (0 = not at all; 1 = a little; 2 = moderately; 3 = quite a lot; 4 = very much). To determine the value corresponding to each of the five variables (tension, depression, anger, fatigue, and vigor), the value given, from 0 to 4, to each question of that dimension was added up. To obtain the value for each game, the sum of the values obtained by all the players in each dimension was averaged, following the methodology by Vega-Marcos et al. (48).

2.4. Procedure

In the present study, all the participants played three games, separated by a 10-minute rest period, with this amount of time being equal to that provided between successive competitive games. Before starting each of the games and selecting the champions with whom the game would be played, the participants self-completed the POMS questionnaire. The values obtained from the POMS questionnaire were used to determine the pre-game moods. Thus, the differences between the mood states prior to the different games played were used to establish the changes produced by the outcome of the games in the psychological state of the players.

The players entered a competitive game, chose their game position (top laner, jungler, mid laner, adc or support) and the champion with whom they would play the game. The LOL matchmaking system, matching players from both teams by ranking, equalizing the level of both teams, allowed the games to be evenly matched, preventing this from conditioning the player's mood before the start of the game (49, 50). The different games were played, during which a record was made of the team performance (game win or lose). After the end of the game, a 10-minute rest period was allowed, and the player returned to fill in the POMS before the next game began. This process was repeated for the three games played by each player.

As these were amateur players, each was allowed to choose the playing position they preferred and in which they felt most comfortable in each game, as this has not been shown to be relevant to the playing experience in previous research (51). In addition, the use of any champion was not limited. The researchers did not give any indication to the player about the composition of the teams, or the champions selected, trying to influence the player's performance and mood as little as possible. Similarly, at the end of the game, there was no interaction with the player so as not to influence his mood, and he was only warned after 10 min to start the next game. Playing with friends was not allowed, as this could affect the player's mood during the game, so he was asked to enter the game alone with four other unknown teammates. The environmental conditions in which the games were played were similar in all games and for all players, with a stable ambient temperature; with no one who could disturb or distract the players during the game, since they were in a separate room; and with ideal light and screen brightness conditions for playing.

2.5. Statistical analysis

The distribution of the data was initially evaluated using the Shapiro-Wilk normality test. As the variables followed a normal distribution, a statistical analysis based on parametric tests was performed. Descriptive statistics were used to find the mean values and standard deviation (M ± SD). A student's *t*-test was conducted to determine differences in players' pregame tension, depression, anger, vigor, and fatigue between games that ended in victory or defeat. A two-way ANOVA with repeated measures was carried out to analyze pre-post game mood change according to the result of the previous and present game. An analysis of the differences in the change produced in the mood prior to the game as a function of the results obtained in the first and second game. Partial eta squared was used to calculate the effect size (ES) and was defined as small: $ES \geq 0.10$; moderate: $ES \geq 0.30$; large: ≥ 1.2; or very large: $ES \geq 2.0$, with an error of $p < 0.05$ (52). A value of $p < 0.05$ was set to determine statistical significance. The statistical analysis was performed with the SPSS statistical package (v. 25.0; SPSS Inc., IL).

3. Results

Table 1 shows the differences in the pre-game mood of the players between the games that ended in victory and defeat. It should be noted that no significant differences were found in the pre-game mood in any of the games played, regardless of the subsequent outcome of the game. For the tension variable, there were no significant pre-game differences in any of the games, regardless of winning or losing ($p = 0.154–0.618$), with the effect size being small in all games; in depression something similar occurred, with no significant differences in any of the games ($p = 0.351–0.898$), with a small effect size; in anger there were also no differences ($p = 0.114–0.897$) and the effect size remained small; as well as in vigor ($p = 0.155–0.399$) and fatigue ($p = 0.138–0.584$) where no differences were found and the effect sizes were small.

Table 2 shows the change in pre-game mood between the first and second game, according to the outcome of the first game, as

TABLE 1 Differences in pre-game mood state between games won and lost.

	Game	Pre-game value (game won)	Pre-game value (game lost)	*t*	*p*	ES
Tension	Game 1	7.50 ± 5.01	8.88 ± 4.94	0.262	0.618	0.021
	Game 2	9.25 ± 5.12	6.83 ± 1.60	1.224	0.290	0.093
	Game 3	8.14 ± 4.26	5.29 ± 2.56	2.312	0.154	0.162
Depression	Game 1	2.17 ± 2.56	2.00 ± 2.20	0.017	0.898	0.001
	Game 2	4.75 ± 5.39	2.50 ± 1.87	0.942	0.351	0.073
	Game 3	2.71 ± 3.64	3.29 ± 3.90	0.080	0.782	0.007
Anger	Game 1	4.33 ± 1.86	7.13 ± 3.64	2.909	0.114	0.195
	Game 2	11.13 ± 9.57	10.50 ± 7.40	0.018	0.897	0.001
	Game 3	9.00 ± 7.57	6.71 ± 4.15	0.490	0.497	0.039
Vigor	Game 1	10.00 ± 3.52	12.12 ± 5.08	0.765	0.399	0.060
	Game 2	9.75 ± 3.54	12.00 ± 4.10	1.214	0.292	0.092
	Game 3	10.86 ± 3.24	8.00 ± 3.79	2.303	0.155	0.161
Fatigue	Game 1	5.17 ± 5.49	3.62 ± 4.75	0.317	0.584	0.026
	Game 2	5.63 ± 5.40	1.83 ± 2.48	2.520	0.138	0.174
	Game 3	4.71 ± 3.40	6.29 ± 6.45	0.325	0.579	0.026

TABLE 2 Differences in pre-game mood state between consecutive games depending on the outcome of the game.

	Game 1 result	Pre-game 1 (I)	Pre-game 2 (J)	Diff. I-J	95% CI diff.	p	ES (η2)	Game 2 result	Pre-game 2 (I)	Pre-game 3 (J)	Diff. I-J	95% CI diff.	p	ES (η2)
Tension	Win	7.50 ± 5.01	6.83 ± 3.49	0.667	−1.676; 3.009	0.547	0.031	Win	9.25 ± 5.12	6.50 ± 4.04	2.750	1.172; 4.328	0.003	0.546
	Lose	8.88 ± 4.94	9.25 ± 4.40	−0.375	−2.403; 1.653	0.694	0.013	Lose	6.83 ± 1.60	7.00 ± 3.52	−0.167	−1.988; 1.655	0.845	0.003
Depression	Win	2.17 ± 2.56	1.17 ± 1.60	1.000	−3.056; 5.056	0.601	0.023	Win	4.75 ± 5.39	2.25 ± 3.58	2.500	−1.705; 6.705	0.220	0.123
	Lose	2.00 ± 2.20	5.75 ± 4.68	−3.750	−7.263; −0.237	0.038	0.311	Lose	2.50 ± 1.87	4.00 ± 3.80	−1.500	−6.355; 3.355	0.514	0.036
Anger	Win	4.33 ± 1.86	3.67 ± 1.211	0.667	−5.411; 6.744	0.815	0.005	Win	11.13 ± 9.57	4.50 ± 2.73	6.625	1.130; 12.120	0.022	0.365
	Lose	7.13 ± 3.64	16.25 ± 7.23	−9.125	−14.388; −3.862	0.003	0.543	Lose	10.50 ± 7.40	12.33 ± 6.38	−1.833	−8.179; 4.512	0.541	0.032
Vigor	Win	10.00 ± 3.52	9.50 ± 4.23	0.500	−1.701; 2.701	0.630	0.020	Win	9.75 ± 3.54	8.75 ± 4.13	1.000	−1.005; 3.005	0.299	0.090
	Lose	12.12 ± 5.08	11.62 ± 3.46	0.500	−1.406; 2.406	0.578	0.026	Lose	12.00 ± 4.10	10.33 ± 3.14	1.667	−0.649; 3.982	0.143	0.170
Fatigue	Win	5.17 ± 5.49	2.33 ± 1.86	2.833	−1.249; 6.915	0.156	0.160	Win	5.63 ± 5.40	6.50 ± 6.37	−0.875	−3.810; 2.060	0.528	0.034
	Lose	3.62 ± 4.75	5.25 ± 5.83	−1.625	−5.160; 1.910	0.336	0.077	Lose	1.83 ± 2.48	4.17 ± 2.23	−2.333	−5.722; 1.056	0.159	0.158

Game 1 is the first game played and game 2 is the second game played.

well as between the second and third game, according to the outcome of the second game. The results obtained showed significant differences in depression ($p = 0.038$) and anger ($p = 0.003$) between the first and second game, with a significant increase in the score of both variables before starting the second game when the first game was lost. Differences between the second and third games were significant in tension ($p = 0.003$) and anger ($p = 0.022$) when the second game was won, with a significant decrease in both variables.

Figure 1 shows the differences in the change of mood pre-post game between the first and second game, according to the outcome of both games. After winning the first and second game, there were only significant differences in fatigue ($p = 0.049$). This is because after the second game there was a considerable increase in this variable, making the change between the two games significant (effect size: 0.334; 95% CI: 0.048; 16.618). In tension ($p = 0.630$; effect size: 0.024; 95% CI: −5.481; 3.481), depression ($p = 0.585$; effect size: 0.031; 95% CI: −8.850; 14.850), anger ($p = 0.930$; effect size: 0. 001; 95% CI: −15.918; 17.252) and vigor ($p = 0.752$; effect size: 0.010; 95% CI: −5.243; 3.909) there were no significant differences after achieving two victories. When the first game was won, but the second game was lost, no significant differences were found in any of the mood states [(tension: $p = 0.747$; effect size: 0.011; 95% CI: 5.148; 3.814); (depression: $p = 0.670$; effect size: 0.019; 95% CI: −9.517; 14.183); (anger: $p = 0.573$; effect size: 0.033; 95% CI: −12.252; 20.918); (vigor: $p = 0.752$; effect size: 0.010; 95% CI: −5.243; 3.909); (fatigue: $p = 0.490$); effect size: 0.049; 95% CI: −5.618; 10.952)]. When the first game was lost but the second game was won, the differences in change were significant in tension ($p = 0.028$; effect size: 0.397; 95% CI: −7.471; −0.529), depression ($p = 0.030$; effect size: 0.389; 95% CI: −19.579; −1.221) and anger ($p = 0.006$; effect size: 0.541; 95% CI: −32.647; −6.953), but not in vigor ($p = 0.807$; effect size: 0.006; 95% CI: −3.145; 3.945) or fatigue ($p = 0.293$; effect size: 0.110; 95% CI: −9.618; 3.218). However, when both games were lost, there was no significant change in either mood [(tension: $p = 0.427$; effect size: 0.064; 95% CI: −2.814; 6.148); (depression: $p = 0.951$; effect size: 0.001; 95% CI: −11.517; 12.183); (anger: $p = 0.254$; effect size: 0.128; 95% CI: −25.585; 7.585); (vigor: $p = 0.175$; effect size: 0.176; 95% CI: −7.576; 1.576); (fatigue: $p = 0.490$); effect size: 0.049; 95% CI: −5.618; 10.952)].

4. Discussion

The aim of the present research was to analyze changes in the mood of amateur LOL players between three consecutive games as a function of the outcome of each game. It is important to note that no significant differences were found in the mood prior to the game, regardless of whether the game ended in victory or defeat. This shows that the initial situation of the players was the same in each of the games, and that it was not determinant for the final result of the game. These results are similar to those found in previous research with professional LOL players, in which the

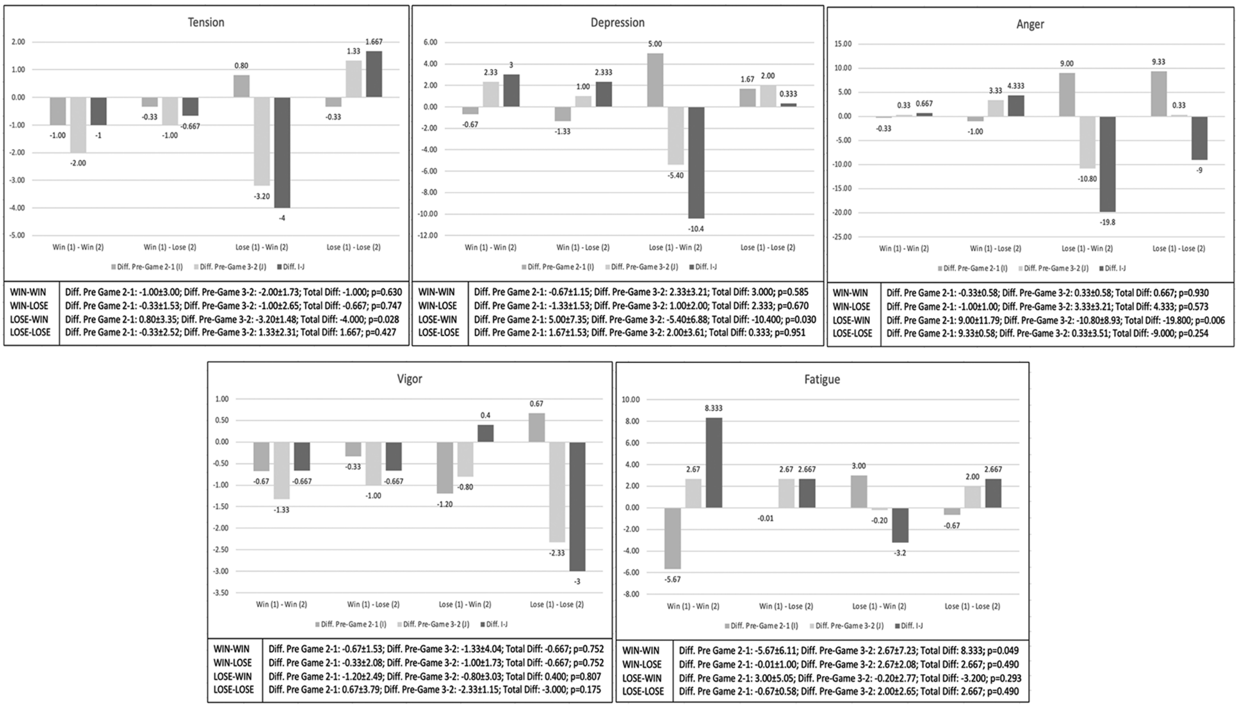

FIGURE 1
Analysis of the change in mood prior to the game based on the results obtained in the first (1) and second (2) games.

pre-game mood of the players was not found to significantly influence whether they won or lost the game (6). A possible explanation for this is that, similar to sports such as soccer, in which the actions in the last minutes of the game are more determinant for victory (53), and the final result does not depend on the players' pre-game mood (54), in LOL the game becomes more important as time progresses, since the players' respawn times are higher and the objectives being fought for become more relevant (18). Therefore, the mood of the players may change throughout the game as the game progresses, as has been seen in traditional modalities (55), and the mood in the final moments of the game may be very important for the final outcome of the competition, to the detriment of the initial mood.

Regarding the evolution of the players' mood with the game result, there was a significant increase in depression and anger before the start of the second game when the players had lost the first game, while there was a significant decrease in anger and tension when they won the second game. These results are particularly novel as no similar research is known in either the professional or amateur field. Previous research in Esports has not analyzed changes between successive games but has shown changes in players' moods based on the outcome of a single game, with decreases in anger after winning the game and increases in depression, anger, fatigue, and confusion after losing the game (6). Therefore, the results of this study confirm that the mood of amateur players undergoes changes depending on the outcome of the game. However, it is of vital importance to consider the outcome of the previous game when analyzing the change in mood in the subsequent games, as in the second game in the present study, the players started with a higher anger and tension value than the basal state before starting the first game.

To understand the importance of the previous result on the mood of the players in the following game, the pre-post game changes produced on the psychological state of the players were analyzed according to the result of the previous and present game. Thus, the results showed that after winning both games, fatigue increased significantly; after winning the first game and losing the second one, no significant differences were found in either mood; after losing the first game and winning the second, there was a significant decrease in tension, depression and anger at the end of the second game; and after losing both games, no significant differences were found in either mood. In the field of sports, previous research in swimming showed that significant changes in tension, anger, fatigue, and confusion were found on several consecutive days of competition, regardless of race results (56). These results could be due to the fact that competition is a stressful event for professional and non-professional athletes, affecting the psychological state of the competitors, among others (57). The present study is the first to analyze the changes in the mood of amateur esports players between games, showing that fatigue increases progressively, even when winning, so rest between consecutive games is essential, and that tension, depression and anger must be controlled after defeat.

In the field of esports only one previous research had analyzed the influence of a congested period of games on the health of players (32). This study showed that in weeks with a high number of games, the quality of players' sleep was impaired (32). The present research provides new and relevant information in this area, following the line of previous research in sports such as basketball in which it was observed that consecutive games affected the psychological state of the players (31) and could be an explanation for the poor quality of players' sleep found by Cook and Charest (32), as fatigue increases with successive games, and other mood states such as tension, depression and anger may also do so as a function of the outcome of the games. However, future research is needed that analyzes the psychological state of players and the quality of players' sleep together, and may even include heart rate analysis, as previous research in traditional sports showed that consecutive games influenced heart rate variability (29), and previous research in esports confirms that the competition and the game situation can produce an activation of the sympathetic nervous system (13), which could affect rest.

In this regard, heart rate and heart rate variability have been used in recent years in the esports field for their potential to monitor player self-regulation (16). Thus, changes in the HRV time-domain variables during the games, as well as a decrease in the mean standard deviation of RR intervals have been observed in the winning teams compared to the losing teams, with some areas of analogous change in heart rate variability also existing in players at the end of matches (17). Similarly, heart rate showed significant differences depending on the play in which the players were involved, with those in which the player was directly involved and favored the team being the most decisive in these changes (7). All of this becomes even more relevant because previous research has suggested that the psychological states of players are related to certain physiological changes, including changes in heart rate (13).

In addition, another relevant aspect for esports performance is eye and cognitive fatigue. In this sense, it has been observed that both factors can be determinant for esports performance, decreasing it as fatigue increases. Although there is no specific research in the field of esports in which the psychological state is related to eye and cognitive fatigue, previous research in other areas can provide relevant information. Thus, in a study carried out with experienced drivers in a driving simulator to try to find out which aspects were most determinant for the onset of fatigue, it was shown that one of the associated factors was negative moods (58). In addition, the sympathetic and parasympathetic nervous systems have been shown to control the relationship between mental fatigue and tonic pupil size and have the potential to indicate mental fatigue (59). Therefore, although future research is required to analyze the most relevant factors in fatigue, mood states could be key in the appearance of visual and cognitive fatigue, as well as in the decrease of performance in esports.

With the results obtained in the present investigation we can partially reject H1 in which it was indicated that the mood of amateur LOL players will be affected by the outcome of each game, with the mood worsening to a greater extent with defeats occurring consecutively compared to defeats following a win. This is because fatigue increased significantly after the games, independently of the final result of the games. However, depression, anger and tension increased with the first defeat, but after the second defeat there was not an even more significant increase.

The results obtained allow the possible extrapolation of these results to the professional environment. Although the findings obtained should be corroborated in future research because the analysis of successive games had not been performed in previous scientific literature, neither in the professional nor amateur field, what is shown is that in successive games the mood of the players is modified by the result of this one, except fatigue that seems to increase regardless of the result. Therefore, the use of certain strategies or psychological interventions between the breaks of competitive games could be considered to readjust the state of mind, predisposing the athlete to face the next game in the best possible conditions. In addition, it seems that the variables on which to influence with psychological intervention could differ depending on the outcome of the game, since depression, anger and tension seemed to fluctuate the most when defeat occurred. The increase in the fatigue variable between successive games is also important because makes it necessary to consider the importance of offering rest to the players between each game played.

In addition, it is important to note that the mood of the players would be affected when they play LOL games. This is decisive, firstly, because defeat in a given game can be the origin of disruptive behaviors in the following games, referring to what is known as tilt in the field of esports (23). Secondly, this could have consequences on the well-being of the players, since subjective well-being is related to moods (60), which is especially relevant in young or vulnerable populations in which competitive video games, such as LOL, could have a negative effect due to the influence of the final result. However, these results should be corroborated in future research, in which it could be analyzed whether victory or defeat in other competitive esports can also affect the mood of players, as this would allow generic recommendations to be made for the population, with special emphasis on the effect that certain video games could have on the most vulnerable populations. Moreover, in LOL, future research should analyze how long it takes for moods that have been altered to return to baseline levels or what strategies can be really useful so that players do not see their games turned into negative gaming experiences.

Therefore, the practical implications of the results obtained in the present investigation are (1) the moods of the final moments of the game seem more relevant than those of the beginning; (2) the outcome of the previous game may be determinant in the mood with which players face the next game, and although the previous mood does not influence game performance, this could be relevant in terms of its effect on sleep, eye and cognitive fatigue, or the associated changes in heart rate. Therefore, the relevance of mood changes is not only due to their direct influence, but to the effect on other physiological variables.

The present study is not free of limitations. The sample was small and was selected by convenience, by choosing the subjects who wished to participate in the research. Regarding the intervention, it should be noted that the exclusive use of the POMS questionnaire provides relevant information, but it only addresses a small part of the psychological domain, so future research should analyze other psychological variables, as well as include other methods such as interviews to gather more information. In addition, other aspects should be considered in future research, since the composition of the team, the playing position, or other factors specific to the game could be determinant in the psychological state of the players. In addition, player mood was not related to players' perception of fatigue. Therefore, future research should assess the perception of fatigue or effort using scales such as the rate of perceived exertion (RPE), which can provide much information by comparing whether the effort that players have perceived to face the game corresponds to their mood, and whether when the effort is greater it affects mood to a greater extent. This becomes even more relevant in situations where several games are played in a row (Bo3 or Bo5) because the fatigue dragged from one game to another can reduce the psychological state with which the next game is faced. Although the games were ranked, the amateur environment lacks professionalism, which could diminish the importance that players attach to winning or losing a game, so future research should be conducted with professional players during competition as the psychological response may be totally different. And finally, the fitness condition of the players (such as the handgrip test), and its possible relationship with performance, was not assessed. Although previous research has shown virtually no relationship between fitness and esports performance (61), this may be because the tests included were limited, not fully assessing players' physical fitness, so future research could examine whether higher performance in certain upper body fitness tests (such as the handgrip strength test) is relevant to esports-specific performance. Taking into account the existing limitations, the present research is a first approximation to the effect that the results of consecutive games can have on the mood of LOL players, which provides very relevant information for the competitive and recreational environments.

5. Conclusions

The mood prior to the game did not seem to be determinant in the subsequent performance during the game. However, the mood of amateur LOL players was influenced by the outcome of the game (win or lose), with an increase in tension, depression and anger found when the game was lost. In addition, analysis of successive games showed that when the first game was lost and the second game was won, the increases in depression and anger found with the first loss were reduced with the subsequent win. However, fatigue was the only state of mind that increased after two consecutive victories, so that the rest time between games becomes very important, especially in amateur players where the time between games is not regulated. The relationship between mood states, well-being, heart rate, and cognitive and visual fatigue are discussed in this research, which gives greater importance to these results, since most amateur gamers use video games as a form of distraction and entertainment, but this aim could be diminished based on the results obtained.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Institutional Ethical Committee of the Catholic University of Murcia. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AM-O: Conceptualization, Data curation, Funding acquisition, Investigation, Writing – original draft. RV-C: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Project administration, Writing – original draft. AG-G: Data curation, Investigation, Methodology, Writing – review & editing. LA-C: Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Exploring actual and perceived levels of physical activity intensity during virtual reality active games

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Background: Research suggests that engaging in active virtual reality (VR) video games can elicit light to moderate levels of physical activity (PA), making it a novel and fun mode of exercise. Further research is needed to understand the influence of VR on perceptions of exertion and enjoyment during PA.

Objective: The objectives of this study are (1) to compare actual and perceived exertion within and between active VR games with varying levels of difficulty and (2) to determine how playing active VR games influences PA enjoyment during gameplay.

Methods: A total of 18 participants completed four separate study sessions, during which they engaged in either a 15-min bout of traditional exercise (stationary cycling) or played one VR game. Heart rate (HR) and ratings of perceived exertion (RPE) using the Borg CR10 scale were assessed during VR gameplay and cycling. Enjoyment was measured after gameplay. VR games included playing Holopoint at level 2 and level 3 and Hot Squat. Repeated measures ANOVAs were used to examine (1) changes in HR and RPE across time within games and (2) differences in actual and perceived levels of intensity and enjoyment between games. Bivariate correlations examined the relationship between the degree of change in actual intensity and the degree of change in perceived intensity during each VR game and cycling.

Results: The analyses revealed that RPE and HR significantly increased from baseline during each condition and generally increased across the 15-min of gameplay. Hot Squat and cycling elicited a significantly higher percentage of heart rate reserve (%HRR) than Holopoint at levels 2 and 3. Holopoint level 3 elicited a higher %HRR than Holopoint level 2. The participants reported greater average and max RPE during Hot Squat and cycling compared with Holopoint at levels 2 and 3. The correlations revealed a significant positive correlation between the degree of change in HR and RPE for cycling, but no significant correlations were observed for any of the VR conditions. The physical activity during Holopoint at both levels was rated as more enjoyable than Hot Squat and cycling.

Conclusion: Our data support the notion that VR has the potential to alter individuals' perceptions of exertion during PA and, in particular, may reduce their awareness of increases in actual exertion.

KEYWORDS

virtual reality, active gaming, perceived exertion, physical activity, exercise intensity

Introduction

Video games have emerged as a primary source of entertainment worldwide. Over 200 million people play video games in the United States, with approximately 40% of that group between the ages of 18 and 35 years old (1). In the past decade, virtual reality (VR) gaming has significantly grown in popularity, with approximately 30% of gamers now owning a VR device (1). VR consoles typically include motion-tracking hand controllers and a headset that displays a fully immersive 3D environment. Player movements are tracked via the controllers and headset, which allow interactions between the player and virtual objects in the 3D environment. Many recent commercial VR video games have been released that require significant movement during gameplay (i.e., Holopoint, Beat Saber). Recent research has evaluated whether active VR games elicit physical activity that can count towards the recommended 150 min of moderate to vigorous aerobic exercise per week (2–5). The results of these studies are mixed and potentially dependent on the type of game and its difficulty level. Finding new and enjoyable modes of exercise is important due to the fact that approximately 40%–50% of young to middle-aged adults do not meet the recommendations for aerobic exercise (6).

The parallel processing model of attention theorizes that attentional strategies can affect the judgment of sensory cues, with dissociative strategies capable of decreasing perceptions of exertion during physical activity (7). Indeed, with a dissociative strategy during exercise, an individual focuses on external cues (e.g., auditory and visual stimuli in the environment) not related to the exercise, thereby providing a distraction from internal sensations. Thus, a potential benefit of exercising via active VR games is that the VR environment could facilitate the use of dissociative attentional strategies and could provide a positive distraction from unpleasant bodily symptoms that arise during higher-intensity physical activity (8). While the research is mixed, several studies have shown that active VR games have the potential to elicit moderate-intensity physical activity while keeping perceived effort lower during gameplay (3, 5). For example, Gomez et al. (3) demonstrated that active VR games, including Holopoint, had higher categorizations of physical activity intensity via objective measures (metabolic equivalents: METS) compared with perceived exertion intensity measures (RPE). Holopoint was perceived as light intensity even though it fell within the moderate category as defined by METs. However, Evans et al. (2) reported similar intensity categorizations based on RPE and percentage of heart rate reserve (%HRR) for VR games Beat Saber, Holopoint, and Hot Squat, with only Hot Squat reaching moderate intensity. Most recently, Stewart et al. (5) revealed that participants' perceptions of exertion were less than their actual exertion when playing the active VR games Fruit Ninja VR, Beat Saber, and Holopoint. A limitation in the Evans and Stewart studies is that actual exertion was measured during gameplay, while perceived exertion was measured after gameplay. Other limitations of prior studies included a lack of an exercise-only control condition (2, 3, 5), implementing a VR environment on a 2D screen (5), and the use of relatively short durations of gameplay (e.g., Gomez and Stewart's studies analyzed only 4–5 min of gameplay). In addition, no studies have evaluated whether participants accurately perceive changes in exertion while playing VR games. Thus, more research is needed to fully understand the influence of VR on perceptions of exertion during physical activity. This is important because prior research has shown that perceived exertion during physical activity can impact adherence to physical activity programs (9).

The current study was designed to address many of the aforementioned limitations by (1) measuring actual and perceived exertion during gameplay over a relatively longer duration, (2) evaluating whether changes in exertion are accurately perceived during VR, and (3) including an exercise control condition. Thus, the overall purpose is to determine whether changes (within a game) and differences (between games) in actual exertion correspond to changes and differences in perceived exertion during VR games with varying levels of difficulty. A secondary purpose is to determine how playing active VR games influenced physical activity enjoyment during gameplay compared with traditional exercise matched for aerobic intensity. Prior research on active VR gaming has evaluated the level of enjoyment but rarely compared it with traditional exercise. Heart rate (HR: actual exertion) and ratings of perceived exertion (RPE) using the Borg CR10 scale were assessed during 15 min of VR gameplay and traditional exercise. VR games included playing Holopoint, at different difficulty settings (level 2 vs. level 3) in separate sessions, and Hot Squat. Holopoint is a game that uses the upper and lower body to dodge incoming targets and hit targets with a bow and arrow. Hot Squat is primarily a lower-body game that requires squatting to avoid incoming objects. The physical difficulty of Hot Squat increases progressively throughout the game. Based on the results of the study conducted by Evans et al. (2), we hypothesized that (1) Hot Squat would elicit higher levels of perceived and actual exertion compared with Holopoint and (2) that playing Holopoint at level 3 would elicit higher actual exertion compared with Holopoint at level 2. Regarding the changes in exertion within a game, we hypothesized that actual and perceived exertion would increase from baseline and across time for all VR games and exercises. However, we also hypothesized that the degree of change in actual intensity would be more strongly associated with the degree of change in perceived intensity during traditional exercise compared with active VR games. This hypothesis is based on the notion that we expect participants to engage in more dissociative strategies during VR compared with traditional exercise (8), thereby leading to less accurate perceptions of exertion.

Materials and methods

Participants

The study included a total of 21 participants (11 males, 10 females) aged between 18 and 34. All participants completed an IRB-approved informed consent form prior to study participation. The participants were recruited from the local university with posted study flyers. The exclusion criteria included (1) motion sickness or claustrophobia, (2) an acute or chronic pain condition, and (3) an answer of "yes" on any of the general health questions on the Physical Activity Readiness Questionnaire (PAR-Q+2019 version) (10). The study session exclusion criteria included eating the hour before each session, consuming alcohol within 24 h of the sessions, participating in vigorous exercise on the day of the sessions prior to the session, and ingesting caffeine or analgesic medications on the day of the sessions prior to the session.

Procedures

This study utilized a repeated measures design in which the participants completed all procedures and conditions. The participants completed five sessions on separate days. The current study is part of a larger study on active gaming and will only include a description of the methods and data relevant to the current study. This study was approved by the Indiana University Institutional Review Board.

Enrollment, screening, and familiarization (beginning of Session 1)

At the beginning of the first study session, the participants signed a written informed consent and completed the PAR-Q+ and a demographics questionnaire to verify eligibility. Then, the participants were familiarized with the Meta Quest 2 VR system (Menlo Park, CA), which includes a headset and two handheld controllers. The VR system tracks the movements of the head and controllers and then translates these movements into the 3D environment displayed on the headset. At the start of Session 1, the participants also completed the International Physical Activity Questionnaire—Short Form (IPAQ-SF) (11) and sat quietly for 10 min to measure their resting heart rate.

TABLE 1 Description of VR games and exercise.

Condition	Description
Holopoint (VR)	Holopoint is a fast-paced archery game in which participants use the controllers as a bow and arrow to hit incoming targets. When the targets are hit, players must dodge the projectiles that fire back at the player. The speed and volume of targets increase with higher levels.
Hot Squat (VR)	Hot Squat is a squatting game to music that requires participants to continually perform squats, and sometimes hold a squat, to avoid incoming objects.
Stationary cycling (non-VR)	Participants rode a stationary bicycle at a predetermined intensity. Participants adjusted speed of cycling to adjust intensity.

Experimental sessions 1–5

Excluding the informed consent, screening, and familiarization procedures in Session 1, the procedures for Sessions 1 through 5 were identical except for the type of activity completed during each session. The participants played one VR game during sessions 1–4, which included Holopoint, Hot Squat, and Relax Walk. Holopoint was played in two separate sessions with one session played at level 2 (L2) and the other at level 3 (L3). Relax Walk is a stationary game, and therefore the session including this game was not included as a part of this study (Relax Walk was part of the larger study). The order of games during sessions 1–4 was randomized. All VR games were played in a 6.5 × 8.5 feet space. See Table 1 for the description of the games. Traditional exercise in the form of stationary cycling was completed during Session 5.

The order of experimental events is depicted in Figure 1. Prior to gameplay, the participants were fitted with a Polar HR monitor consisting of an HR sensor placed around the chest and a wristwatch placed on the non-dominant wrist. Then, the participants played the assigned game or rode the stationary bike at a very light intensity for 5 min for familiarization and then sat quietly for 10 min to allow HR to return to rest. Next, the participants played the assigned game or rode the bike for 15 min. During Session 5, the intensity of the stationary cycling was matched to the intensity (based on HR) of the highest intensity played during VR gameplay. For example, if a participant played Hot Squat at the highest intensity based on HR, then the average HR during Hot Squat for minutes 1–5, 5–10, and 11–15 was determined for that participant. If the average HR for Hot Squat for minutes 1–5 was 115 beats, then a target HR range of 110–120 (average ±5) beats was created for minutes 1–5 on the bike. The experimenter instructed the participant to

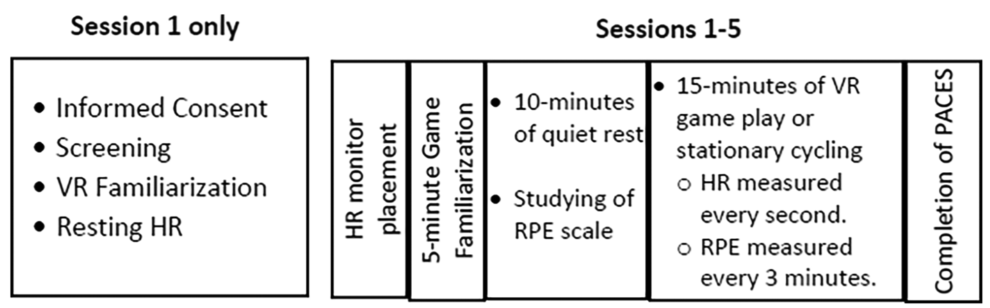

FIGURE 1
Order of experimental events. VR, virtual reality; HR, heart rate; RPE, ratings of perceived exertion.

bike faster or slower to keep their HR within the target range. During each 15-min bout of gameplay or exercise, HR was continuously monitored, and RPE using the Borg CR10 scale was assessed every 3 min. The modified Physical Activity Enjoyment Scale (PACES) was completed after the 15-min bout of activity.

Outcome measures

Measures of actual exertion

A Polar HR monitor (Polar, Kempele, Finland) was used to measure HR every second during gameplay. The HR measured at baseline (just prior to starting the activity) and during the middle 13 min (i.e., excluding the first and last minute) of the 15-min period was used for data analyses. Raw HR values were averaged for minutes 1–4, 5–9, and 10–14. The maximum HR value and average HR value for minutes 2–14 were also recorded. Max HR was determined by the maximum HR value recorded during minutes 2–14 of gameplay. The max and average HR values were used to calculate the percentage of max and average HR reserve (%HRR) values for each game and exercise. The percentage of HRR was calculated with the following formula: [(HR during activity − resting HR)/HRR] × 100, with HRR = maximum age-related HR − resting HR. The maximum age-related HR was calculated with the standard formula of 220 − age. The %HRR ranges that were used to determine physical activity intensity were the following: light: 30%–39%, moderate: 40%–59%, and vigorous: ≥60%) (12, 13). We also calculated the percentage of time that the participants were in moderate to vigorous intensity during the 15-min bout (i.e., %HRR values that were ≥40% for each second of gameplay). In sum, the following measures were extracted from HR to represent actual exertion: average %HRR, max %HRR, and percent of time in moderate to vigorous physical activity (MVPA).

Measure of perceived exertion

During the 15-min bout, the participants were asked to rate their exertion levels using the 0–10 Borg Category-Ratio scale (Borg CR10), where 0 indicates "nothing at all" and 10 represents "extremely strong—Maximal" (14). Specifically, the participants were instructed, "When rating exertion give a number that corresponds to how hard and strenuous you perceive the activity to be. The perception of exertion is mainly felt as strain and fatigue in your muscles and as breathlessness." The participants were also told that it is important to report what they actually experience or feel, not what they think they should report (14). During the 10 min of quiet rest between familiarization and the 15-min activity bout, the participants were given the Borg CR10 scale to study since they would be asked to give ratings without viewing the scale. The participants were asked to give RPE ratings at baseline and 3, 6, 9, 12, and 15 min of the 15-min bout while still wearing the VR headset. Thus, the participants could not see the scale while giving a rating. To mimic the VR sessions, the participants also did not have access to the scale during stationary cycling. The average RPE and maximum RPE were calculated based on the five ratings provided during gameplay or exercise.

Enjoyment

Upon the completion of each active game, the participants were asked to complete the modified Physical Activity Enjoyment Scale (PACES). The PACES includes five Likert-style questions related to enjoyment of the activity. The PACES questionnaire consisted of items rated on a seven-point scale, assessing perceived feelings that ranged from (1) enjoy to hate, (2) dislike to like, (3) fun to no fun, (4) feel good physically to feel bad physically, and (5) frustrated to not frustrated. The participants were instructed to rate how they felt about the physical activity they had recently engaged in. Each question had a maximum score of seven. The percentage of the sum of the individual questions out of 35 for PACES was used in the statistical analysis, with higher scores indicating greater enjoyment. The PACES has been used in prior active gaming studies and is a validated tool (15–18).

Statistical analysis

Statistical analyses were conducted with SPSS v29 (IBM Corporation, Armonk, NY). Descriptive characteristics were calculated for all primary variables. Raw HR values were averaged for minutes 1–4, 5–9, and 10–14. We conducted a 4 (Condition) × 4 (time: baseline, 1–4 min, 5–9 min, 10–14 min) repeated measures ANOVA to examine changes across time in HR for each condition. Similarly, we conducted a 4 (condition) × 6 (time: baseline, 3, 6, 9, 12, 15 min) repeated measures ANOVA to examine the changes across time in RPE for each condition. To examine the differences in the actual exercise intensity between games, the percentage of time in MVPA, average %HRR, and max %HRR were analyzed with separate one-way repeated measures ANOVAs. To examine the differences in perceived intensity and enjoyment between games, the average RPE, max RPE, and PACES scores were analyzed with separate one-way repeated measures ANOVAs. *Post-hoc* analyses were conducted using simple effects tests for analyzing significant interactions, and *t*-tests with Bonferroni corrections were conducted for assessing significant main and simple effects.

We also examined whether the degree of change (within a game) in actual intensity correlated with the degree of change in perceived intensity during each VR game and stationary cycling. The degree of change was evaluated by calculating the slope of the change in intensity from minute 3 to minute 12 in %HRR and RPE. The average %HRR was calculated for minute 3 and minute 12 of gameplay and stationary cycling. Minutes 3 and 12 were chosen because we expected the participants to be in a steady state during these time points. The slope of the line representing a change in intensity from minute 3 to minute 12 was calculated with the following formulas: slope for RPE = (minute 12 RPE − minute 3 RPE)/(12 − 3) or slope for %HRR = (minute 12%HRR − minute 3%HRR)/(12 − 3). Bivariate correlations were conducted between the %HRR slope and RPE slope for each VR game and cycling. Significance was set at $p < .05$.

Results

Of the 21 participants enrolled in this study, a total of 18 participants completed all of the required conditions (11 males, average age = 23.8 years, SD = 4.7) and were included in the data analyses. The data of two participants were excluded due to the inaccurate collection of HR measurements during one of the games. Another participant's data was excluded due to their failure to complete the stationary cycling session. The average IPAQ-SF total score was 4,861.75 ± 3,693.9, indicating that the participants in the sample were highly physically active.

Changes across time in HR and RPE between conditions

Heart rate

The two-way ANOVA revealed a main effect of condition ($p < .001$) and time ($p < .001$), which were superseded by a significant interaction, $p < .001$. The simple effects tests of time within each condition were significant ($p < .001$). The significant follow-up tests revealed the following differences across time: (1) All games increased HR from baseline to each time point, (2) minutes 11–14 were greater than minutes 1–4 and 5–9 for Holopoint L2, and (3) HR significantly increased across all time points for Hot Squat and cycling. The simple effects tests of condition within each level of time were significant (baseline $p = .009$, minutes 1–4 $p = .003$, minutes 5–10 $p < .001$, minutes 11–14 $p < .001$). The following significant differences were revealed between games: (1) Hot Squat had greater HR than Holopoint L2 at baseline, (2) Hot Squat had greater HR than Holopoint L2 and Holopoint L3 at minutes 1–4, and (3) Hot Squat and cycling had greater HR than Holopoint L2 and Holopoint L3 at minutes 5–10 and 11–14. Holopoint L3 also had greater HR than Holopoint L2 at minutes 5–10. See Figure 2A for the HR values for each condition across time.

Ratings of perceived exertion

The two-way ANOVA revealed a main effect of condition ($p < .001$) and time ($p < .001$), which were superseded by a significant interaction, $p = .003$. The simple effects tests of condition within each level of time were significant for time points 6 ($p = .040$), 9 ($p = .008$), 12 ($p = .003$), and 15 ($p < .001$) minutes. Follow-up tests indicated the following significant differences: (1) Hot Squat had greater RPE than Holopoint L3 at 6 min, (2) Hot Squat had greater RPE than Holopoint L2 and Holopoint L3 at 9 min, (3) Hot Squat and cycling had greater RPE than Holopoint L2 at 12 min. (also, Hot Squat had greater RPE than Holopoint L3 at 12 min), and (4) Hot Squat and cycling had greater RPE than Holopoint L2 and Holopoint L3 at 15 min. The simple effects tests of time within each condition were all significant, $p < .001$. The following differences were found for each game: Holopoint L2: baseline < all timepoints, 3 < 9–15 min, and 6 and 9 < 15 min; Holopoint L3: baseline < all timepoints, 3 < 6–15 min, 6 < 12–15 min, and 9 < 15 min; Hot Squat: baseline < all timepoints, 3 < 6–15 min, 6 < 12–15 min, and 9 < 15 min; cycling: baseline < 3 min < 6 min < 9 min < 12 and 15 min. See Figure 2B for RPE values for each condition across time.

Differences in actual and perceived intensity and enjoyment between games

See Table 2 for the means and standard deviations for each variable for each condition.

Actual intensity

Percent of time in MVPA (>40% HRR)

The repeated measures ANOVA was significant, $p < .001$. The significant follow-up tests indicated that Hot Squat and cycling had greater MVPA than Holopoint L2 and Holopoint L3. Holopoint L3 also had greater MVPA than Holopoint L2.

Average %HRR

The repeated measures ANOVA was significant, $p < .001$. The significant follow-up tests indicated the following differences in average %HRR: Holopoint L2 < Holopoint L3 < Hot Squat and cycling. Based on the %HRR values, Holopoint L2 and L3 were played at a light intensity, while Hot Squat and cycling were completed at a moderate intensity.

Max %HRR

The repeated measures ANOVA was significant, $p < .001$. The significant follow-up tests indicated that Hot Squat elicited higher max %HRR compared with all conditions. Also, cycling had a greater max %HRR compared with Holopoint L2. Based on the max %HRR values, the max intensity reached during Holopoint was moderate, while vigorous intensity was reached during Hot Squat and cycling.

Perceived intensity

Average RPE

The repeated measures ANOVA was significant, $p < .001$. The significant follow-up tests indicated that the participants reported greater RPE during Hot Squat compared with Holopoint at either level. No differences were evident between Holopoint L3 and Holopoint L2 in perceived exertion.

Max RPE

The repeated measures ANOVA was significant, $p < .001$. The significant follow-up tests indicated that the participants reported greater max RPE during Hot Squat and cycling compared with Holopoint at either level.

Enjoyment

The repeated measures ANOVA was significant, $p < .001$. The significant follow-up tests indicated that the participants reported greater enjoyment of physical activity during Holopoint L2 and L3 compared with Hot Squat and cycling.

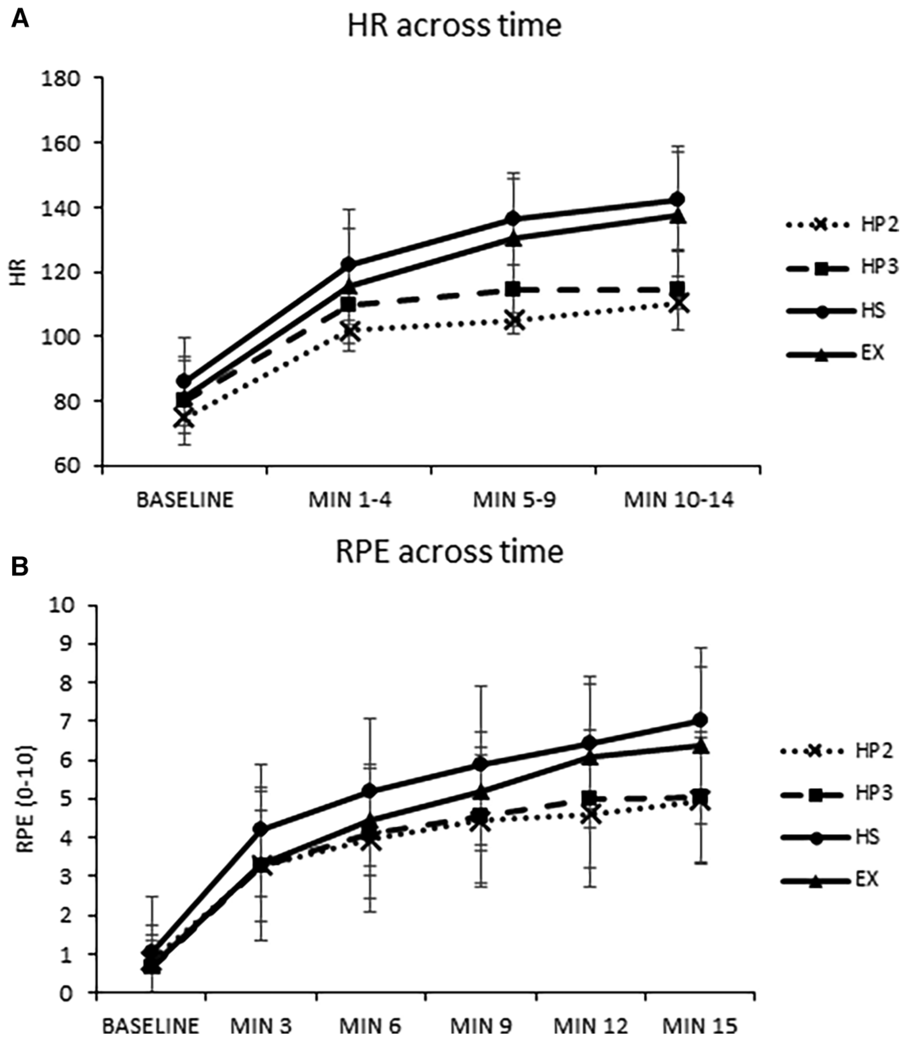

FIGURE 2
(A) Heart rate (HR) across time for each condition; (B) ratings of perceived exertion (RPE) across time for each condition. Min, minutes; HP2, Holopoint level 2; HP3, Holopoint level 3; HS, Hot Squat; EX, exercise (stationary cycling).

TABLE 2 Means and standard deviations (SD) for actual exertion variables, perceived exertion variables, and enjoyment.

	Holopoint L2	Holopoint L3	Hot Squat	Cycling
% of time in MVPA	28.9 ± 30.2	49.6 ± 33.6	78.4 ± 14.7	74.0 ± 29.7
Average %HRR	33.7 ± 7.8	39.3 ± 8.6	54.3 ± 9.6	50.3 ± 12.6
Max %HRR	47.7 ± 11.8	52.8 ± 13.2	74.1 ± 12.0	64.6 ± 15.4
Average RPE	3.7 ± 1.5	3.8 ± 1.4	4.9 ± 1.4	4.4 ± 1.3
Max RPE	5.1 ± 1.8	5.2 ± 1.8	7.2 ± 1.8	6.4 ± 2.1
Enjoyment	88.6 ± 9.8	88.9 ± 8.9	67.9 ± 14.4	63.7 ± 20.0

%, percentage; L2, level 2; L3, level 3; HRR, heart rate reserve; RPE, ratings of perceived exertion.

Correlations between the change in actual intensity with the change in perceived intensity within games

See Table 3 for the correlation coefficient and *p*-values. No significant correlations existed for the active VR games between the %HRR slope and RPE slope. Thus, the degree of change in actual exertion was not associated with the degree of change in perceived exertion from minute 3 to minute 12 of VR gameplay. However, the %HRR slope and RPE slope were significantly and positively correlated for cycling. Thus, greater increases in actual exertion were associated with greater increases in perceived exertion during cycling.

TABLE 3 Bivariate correlations of the degree of change in actual exertion (average %HRR) with the degree of change in perceived exertion for each VR game and exercise.

Condition	*r*-value	*p*-value
Holopoint L2	0.072	0.777
Holopoint L3	0.289	0.249
Hot Squat	0.208	0.406
Cycling	0.559	0.016*

Note. The degree of change is measured by the slope of the line from 3 to 12 min. L2, level 2; L3, level 3.
*Significant at $p < .05$.

Discussion

The current study was designed to further elucidate the relationship between actual and perceived exertion during physical activity performed in active VR games. Several key findings emerged from this study. First, the actual intensity of the VR games reached moderate to vigorous, although this intensity was not maintained for the entire period of gaming. Second, increasing the difficulty level of Holopoint leads to greater actual exertion but not greater perceived exertion during gameplay. Third, the participants accurately perceived their increases in exertion during stationary cycling, but not during VR gameplay.

Based on prior research (2), we hypothesized that Hot Squat would elicit higher levels of perceived and actual exertion compared with Holopoint. We also hypothesized that increasing the difficulty level for Holopoint would increase the exercise intensity of gameplay. These hypotheses were generally supported. According to the data, approximately 75% of gameplay was spent in MVPA during Hot Squat, while approximately 50% of gameplay during Holopoint L3 was spent in MVPA, and only 30% for Holopoint L2. Prior studies have shown mixed results regarding the level of physical activity intensity obtained during Holopoint. Gomez et al. (3) demonstrated that the participants reached a moderate intensity based on METS while playing Holopoint in a customized setting, which provided a challenging difficulty level for the participants. Alternatively, Evans et al. (2) revealed that the participants played Holopoint L2 at a light intensity. The current study indicated that physical activity intensity during Holopoint is partially a function of difficulty level. It remains unknown whether further increases in Holopoint levels (higher than level 3) would result in additional gains in MVPA. Overall, our results suggest that playing these games could contribute toward the objective of obtaining 150 min of MVPA per week, with the caveat that the amount of MVPA during gameplay is likely to be less than the total duration of playtime.

In line with the parallel processing model of attention (7), a hypothesized benefit of exercising via active VR games is that the VR environment could facilitate the use of dissociative attentional strategies, in which attention is shifted from unpleasant bodily symptoms that arise during higher-intensity physical activity to the external cues of the VR game. This focus on the VR environment could then lead to an underestimation of perceived exertion during active VR games. For example, Neumann and Moffitt (8) showed that the participants running on a treadmill in a 2D VR environment (similar to watching TV) focused more attention on external task-relevant stimuli and less on internal states compared with the participants viewing neutral images while running. Additional research has shown that the participants achieve higher actual exertion during VR gameplay compared with perceived exertion for several different VR games, including Holopoint (3, 5). Our results revealed that perceived exertion was greater for Hot Squat and cycling compared with Holopoint, which was similar to the actual exertion differences. Hot Squat and cycling were rated as strong to very strong exertion, while Holopoint regardless of level was rated as moderate to strong exertion. Interestingly, even though actual exertion was higher for Holopoint L3 compared with Holopoint L2, the participants rated perceived exertion as similar between the two Holopoint levels. Thus, the more challenging levels of this game lead to greater actual exertion but not perceived exertion during gameplay. In addition, Hot Squat elicited a higher maximum actual exertion compared with cycling; however, maximum perceived exertion did not differ between Hot Squat and cycling statistically. Thus, the perceived differences in maximum exertion between Hot Squat and cycling were not as strong as the actual differences in maximum exertion. In general, these results support prior studies showing an underestimation of exertion with active VR gameplay.

In contrast to prior studies on active VR, we evaluated changes in actual and perceived exertion across time during gameplay. Supporting our hypothesis, each game increased perceived and actual exertion from baseline, with exertion generally increasing across time. Hot Squat and cycling elicited greater increases in actual and perceived exertion compared with Holopoint at both levels. The results also revealed that the participants accurately perceived their increases in exertion in our control condition, stationary cycling. Increases in actual intensity from 3 to 12 min positively correlated with increases in perceived intensity from 3 to 12 min. However, the data indicated no associations between the change in perceived and actual intensity for the VR games. While the correlation coefficients were positive for the VR games, they were small and non-significant. Thus, as the VR games progress, the participants may not accurately perceive changes in exercise intensity. It should be noted that the exercise intensity for cycling was matched to the highest intensity during VR gameplay for each individual. Thus, the participants were instructed by the experimenter to cycle faster or slower to keep HR within a target HR range. These cues, not present during VR gameplay, could have strengthened the relationship between actual and perceived exertion during stationary cycling compared with VR.

Few active gaming VR studies have evaluated the enjoyment of physical activity during VR games compared with traditional forms of exercise. The results of the present study indicated that the physical activity during Holopoint at L2 and L3 was rated more enjoyable than the physical activity during Hot Squat and stationary cycling, with no differences between the latter two conditions. Other studies have also found Holopoint to be highly enjoyable (2, 5). Moreover, McDonough and colleagues (19) evaluated physical activity enjoyment during traditional stationary cycling, a VR cycling session, and an exergame cycling session. While the physical activity intensity was not measured or standardized across the conditions, enjoyment was higher and RPE was lower for the VR cycling session compared with other cycling conditions. Finding enjoyable options for moderate-intensity physical activity participation is important because greater enjoyment or pleasure of exercise is associated with greater MVPA in the future (20, 21).

This study had several limitations. First, we suggested that the underestimation or inaccurate perceptions of exertion during VR are a result of participant immersion in the VR environment or game, which diverts attention away from unpleasant bodily symptoms. However, the current study did not actually measure attention strategies during gameplay, and this could be an important avenue for future research. In addition, based on the results of the IPAQ, the sample of the current study would be categorized as very active. The generalizability of these results to a sedentary population remains unknown. Finally, prior VR studies have used Borg's 6–20 RPE scale to measure perceived exertion, which has validated intensity categorizations based on the numerical rating given (i.e., 9–11 = light, 12–13 = moderate, etc.). The Borg CR10 RPE scale used in the present study does not have such validated intensity categorizations. Thus, we could not make intensity categorization comparisons based on RPE and %HRR data. The CR10 RPE scale was chosen based on the assumption that it would be more intuitive for the participants compared to the 6–20 scale, given that the participants had to provide ratings over a period of time without being able to see the scale.

In conclusion, our data support the notion that virtual reality may alter perceptions of exertion during physical activity and, in particular, may dampen the awareness of increases in actual exertion. Importantly, prior research indicates a negative association between perceived effort and adherence to physical activity programs (9). Thus, future research should explore whether the implementation of active VR games into physical activity programs can facilitate adherence. Furthermore, while underestimations of perceived exertion are generally assumed to have positive benefits, this phenomenon could also lead to over-exercise or over-exertion. This possibility would be important to monitor during active VR games, particularly in vulnerable populations such as older adults.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Indiana University Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

KN: Conceptualization, Funding acquisition, Supervision, Writing – original draft. XC: Data curation, Funding acquisition, Methodology, Writing – review & editing. CB: Data curation, Methodology, Writing – review & editing. BW: Data curation, Methodology, Writing – review & editing. KN: Conceptualization, Formal Analysis, Project administration, Supervision, Writing – original draft.

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Parental support in esports through the lens of the theory of planned behaviour

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Esports have grown substantially in the last decade and may be an effective way of engaging and exposing the youth, who is not actively participating in traditional sports, to the benefits of sports related performance environments. However, due to negative stereotypes about gamers and concerns about esports, parents might be hesitant to support their children's esports participation and may instead actively discourage it. The purpose of this perspective article was to discuss the determinants of parental support based on the theory of planned behaviour. Parents attitudes seem to be mostly negative and their perceived behavioral control is likely low due to a lack of knowledge about esports. The subjective norms are mixed and seem to be growing progressively more positive. Based on the theory of planned behaviour, parents seem unlikely to support their children's esport participation, however, more research is needed. Recommendations on how to increase the likelihood of parental support are discussed.

KEYWORDS

esports, support, attitudes, structure, concern, physical activity

1 Introduction

Electronic sports (esport) have grown substantially in popularity and market value over the last decade (1). Researchers recognize the potential of esports to attract young people [e.g., (2)] and cultivate a healthy lifestyle (3). Esports may be a new effective way to reach the approximately 20% of youth who are not engaged in the performance environments of traditional sports (4) and lead to many positive developmental outcomes [e.g., (5)]. For instance, esports programs have been effective at improving social-emotional and communication skills, leading to better social relationships outside the esports club [e.g., (6)]. Grassroots esports may also be an effective context to promote physical activity (PA) among youth, especially when aligned with a creative emphasis on play and enjoyment, rather than framing it as a mere "training" exercise (7). Although esports offers a unique and perhaps counterintuitive setting to foster healthy psychological development and health behaviour change (8), parents might be reluctant to support their children's esport involvement due to the negative stereotypes about video gamers [e.g., socially inept couch potatoes (9)] and negative beliefs about esports (10).

Parents play an important role in influencing and guiding youths' involvement in structured activities (11) aimed at promoting positive adjustment and development (12). For example, in Nordic high school esports programs, the majority of parents (58%) whose children were involved either expressed no opinion, disagreed with, or actively discouraged their children's participation (13). Without parental support children may quit esports (14) or engage in unstructured play, lacking many essential components seen in organized sports activities including; supervision, guidance from adult leaders, rules, and structured practice and play [e.g., (15)]. The absence of these components has been associated with increased odds of health risk behaviors such as smoking, alcohol consumption and worsened academic achievement among youth (16). Parental support likely plays a pivotal role in children's esport participation, representing a relatively unexplored research area dependent on parental attitudes toward esports.

2 Theory of planned behaviour

The theory of planned behaviour (TPB) is a framework that has been used to understand and predict behaviours (17). According to the TPB (18), an individual's behaviour is determined by the individual's intention, which is influenced by the determinants of intention; the individual's attitude, perceived behavioural control (PBC) and subjective norms (17). The subjective norm pertains to the opinion of a specific reference group (spouse, family, co-workers) regarding a behaviour, including whether they approve or disapprove of the behaviour and whether they themselves engage in it. Attitudes involve a mixture of the individual's beliefs about the experience of engaging in a specific behaviour and its outcome. Positive attitudes are more likely to strengthen an individual's intention to change their behaviour. PBC is an individual's ability to exert control over a behaviour. PBC may be influenced by factors such as previous experience and social support. The determinants of intention impact the individual's intentions towards the behaviour which in turn impacts the behaviour. The theory has been successful in explaining and predicting behaviours in a wide array of domains such as physical activity (17), esport (19) and smoking (20). TPB is grounded in the target behaviour, which is influenced by the strength of an individual's intention toward that behaviour. Furthermore, TPB posits that intentions are directly influenced by subjective norms, an individual's attitudes, and the degree of behavioural control (see Figure 1). However, individuals can be influenced by barriers such as limited time, financial constraints, inadequate skills, and a lack of resources, even if they have the intention to make a change. Furthermore, intentions toward a given behaviour are also impacted by subjective norms and personal attitudes. Subjective norms, attitudes, and PBC are based on anticipated outcomes rather than the actual outcomes. Moreover, attitudes toward a behaviour may change due to participation in the behaviour (17). Overall, the model has been used to predict and better understand behaviours in several domains including esports (10), exercise, and healthy diets (21).

3 Parents beliefs and attitudes towards esports

Studies have explored attitudes toward different aspects of esports such as participation, careers, and school competitions (10, 22). Regarding esport school competitions, Cho et al. (22) found that parents were resistant and bewildered towards the incorporation of esport in the classroom. Esport players had to negotiate with their parents to be allowed to participate in esports, often committing to dedicating time to homework to secure permission for participation (22). Similarly, a significant proportion of parents (58%) with children involved in high school esports in Scandinavia expressed either no opinion (44%), disagreement (7%), or actively discouraged (7%) their children's participation in high school esports programs (13). Wong et al. (10) supported this by highlighting that a considerable number of parents were hesitant and expressed negative attitudes towards their children's esports participation. This reluctance stemmed primarily from the belief that esports could detract time from academic studies. Esport players have themselves reported difficulties in balancing academics with esports (10). In addition, parents have discussed concerns about perceiving esports as insecure employment (23), a potential risk factor for video game addiction (24), and decreased mental and physical health (25). Another contributing factor to parents' resistance might be the novelty of esports with parents being unfamiliar with esports and its distinction from video gaming (24). Due to these perceptions, many parents might be unsupportive toward their children pursuing esport careers (23). However, research has shown that the resistance from parents toward esport participation decreases when esport players become successful (10). Similarly, more positive media coverage of esports may erode parents negative attitudes and resistance to their children's participation (25). Although existing research provides insights into the extent of parental support for their children's esports participation (13) and the relationship between parental support and children's esports participation (10), there is a need for a more detailed understanding of the factors influencing these attitudes.

4 Subjective norms

Subjective norms regard different referent groups' opinions about the behaviour. As the population of parents is broad, the following referent groups will be addressed briefly; the general public, the state, and sports organisations. Importantly, parents likely have other parents as a referent group but as their attitudes toward esport were previously discussed they will not be discussed in this section.

4.1 The general public

When discussing esports it is important to keep in mind that they are hardly distinguishable from video games to the general population (10), as such it is relevant to include video games. Madrigal-Pana et al. (26) found that older participants (75.4% of participants aged >50) displayed more negative attitudes toward video games compared to their younger counterparts (49.8% of participants aged 18–29). Common negative beliefs included the notion that video games cause addiction (75.5%) and negatively affect health (51.3%). However, participants also held positive

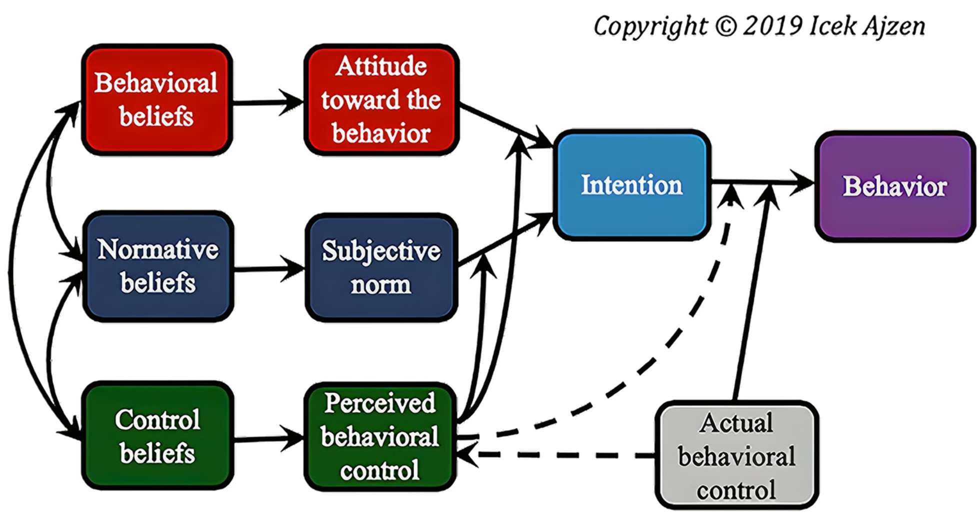

FIGURE 1
Theory of planned behaviour. From theory of planned behaviour by Ajzen (51) https://people.umass.edu/aizen/tpb.diag.html.

beliefs, such as video games stimulating mental abilities (59.6%), providing relaxation from daily life (55.2%), and communication within a family environment (49.4%) (26). Given that concerns about video game addiction and health are significant issues related to esports, targeting these beliefs could potentially contribute to more positive subjective norms.

4.2 The state and sports organisations

There has been a growing number of countries recognizing esports as a sport, which could legitimize esports. For example, in 2003 only South Korea, China and Russia recognized esport as a sport. In 2023, over 14 countries recognized esport as sports [e.g., (27, 28)]. In 2021, Jenny et al. (29) reported that 74 higher institutions worldwide offer esport-related degrees ranging from courses to bachelor's and master's degrees in areas such as business/management and media/communication. Some countries such as the USA have started offering scholarships for esport players (30). Other countries have put finances towards health promotion initiatives in esports (7). The Danish government has appointed an esport panel to make recommendations about topics like talent development, sustainability, exercise, laws and rules (31). The state's position on esport seems to differ largely depending on the country. Parents in different countries might therefore be more or less positive towards esports.

Similarly, sports organisations have given esports increased recognition. Large organisations such as NHL (32), NBA (33) and FIFA (34) have organized esport leagues and championships. Esports have also been incorporated into prestigious events such as the Asian Games (35), and the Olympic Games via the Olympic Esport series (36). The acceptance of esports from large sports organisations is important as it helps legitimize esport within society and may be an influential subjective norm.

5 Perceived behavioural control

Multiple factors can influence PBC such as skills, ability, time, and money (17). Regarding skill and ability, esports is a new industry and parents may lack knowledge of esports (24). More specifically, parents might lack understanding of how esports are played, what esport practice entails (7) and time to support and guide their children through esports (23). Furthermore, parents also seem to lack interest in esports and might therefore not take the time to amend their lack of knowledge (7). As such, from a skill and ability perspective, parents may have a low PBC. Regarding the financial aspects, costs can be a barrier to sports participation (37). While this may apply to esports participation as well, a significant amount of players engage in esports. For example, the esport League of Legends has 180 million active players (38), while the esports Valorant and Counter-strike 2 have 22 million and 752 thousand active players respectively [(e.g., (39, 40)]. Although further research is needed to understand the effect of financial investments on esports participation, these numbers illustrate that many people have the necessary equipment. However, parents might lack knowledge about esport and may feel ill equipped to provide support (23). For example, esport players have reported frustration related to equipment issues (41). Without good knowledge in esports, parents will likely feel ill equipped to help solve the issues. Furthermore, esport players are less likely to seek parental support and advice due to their parents' limited knowledge about esports (23). This reluctance may be amplified during adolescence, a phase when individuals typically seek greater independence (42). If the children are unwilling to receive parental support, it might also be difficult for parents to provide support. In summary, parents may feel high PBC concerning financial and time aspects, but lower PBC related to their ability and knowledge of esports and their children's resistance toward support.

6 Practical recommendations

Based on the determinants of behaviour (i.e., attitudes, social norms and PBC parents seem unlikely to support their children's esport participation. If attitudes toward esports and parents PBC became more positive the likelihood of parental support could be increased. Attitudes toward esport seem to be mostly concerned with health aspects (addiction and physical health), academic success, and future careers. It is unclear if esport players meet the physical activity recommendations as researchers have found that that esport players both meet [e.g., (43, 44)] and do not meet the guidelines [(e.g., (45, 46)]. Regardless, if esport players meet the physical activity recommendations or not, parents could play an active role in their children's esport participation and provide a structure that incorporates physical activity, thereby helping their children meet the physical activity guidelines whilst getting the benefits of structured activities.

Regarding academic success parents are concerned that esports might distract esport players from studying (23). This concern has been echoed by esport players, discussing the difficulties of balancing academics with esports [e.g., (10)]. Another concern from parents relates to the future career prospects associated with becoming a professional esport player (23). Esports are highly competitive (14) and the average career span is relatively short (47). There are, however, several esports-related jobs that players could pursue if they fail to become professional players (29), including esport coach, broadcaster and HR manager [for an extensive list of esport related jobs see Scott et al. (48)]. Esport players also develop transferable skills that could help them in other jobs (49). Furthermore, parental support and the provision of structure could help esport players better balance esports with academics, which could provide a backup plan if their esports pursuits fail.

Regarding PBC, parents seem to be lacking in esports knowledge (23) which could hinder them from supporting their children even if they wanted to. Parents who lack knowledge in esports would likely benefit from receiving information and guidelines from fields such as sport psychology to help them better structure their children's esport participation (5). For example, information from sport psychology could aid parents in developing their children's ability to develop a growth mindset, set appropriate goals and cope with harassment which have been detailed as important mental skills for esport players [e.g., (50)]. Initiatives such as the Danish initiative to incorporate esport into traditional sports clubs (7) could also be helpful as they remove competence requirements on the parents.

7 Future research

Given the limited research on parents' attitudes toward esports, a primary focus should be placed on gaining a better understanding of this aspect. Given that esports have been recognized as an avenue for physical and psychological development of young individuals (8), it is important to highlight the need for further investigation into concerns about potential negative impacts of youth esports (4, 24). Furthermore, attitudes toward esport could differ between different countries and cultural contexts. As such, it could be interesting to explore parental support based on a TPB perspective from different countries and cultural contexts. Future research could also explore which determinant of behaviour (i.e., attitudes, subjective norm and PBC) is most impactful in improving parental support. Another important aspect of research involves investigating where negative attitudes and public perceptions of esports diverge from reality (9). This research is needed for esports clubs and school programs to effectively educate the public about the potential health promotion role that esports can fulfill.

8 Conclusion

Esports, especially structured esports have many potential benefits, but parents might be hesitant to support their children's esport participation. Lack of parental support places children at a higher risk of missing out on positive outcomes associated with esports and structured activities, making them more prone to experiencing potential negative consequences. Parental support is determined by their attitudes, PBC, and social norms (51). Parents' social norms appear varied, but parental attitudes and PBC predominantly lean toward the negative spectrum. The negative attitudes revolve around concerns about their children's health and academic success, while the lack of PBC is based on a lack of knowledge about esports. Enhanced positive exposure to esports and the provision of guidelines for children's esports participation could contribute to more positive parental attitudes and improved esports competence. This, in turn, may increase the likelihood of parental support, allowing children to derive the benefits of structured activities.

Author contributions

JS: Conceptualization, Writing – original draft, Writing – review & editing. OL: Writing – review & editing. MT: Conceptualization, Supervision, Writing – original draft, Writing – review & editing.

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Fighting fair: community perspectives on the fairness of performance enhancement in esports

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Aims: This study aims to explore community perspectives on enhancer usage in competitive gaming and esports, focusing on the perception of fairness and concerns about various potential performance enhancers.
Methods: We conducted both qualitative and quantitative surveys to understand the competitive gaming community's opinions on different types of performance enhancers and their potential impact on esports. A thematic analysis was performed to identify key themes in how players rationalize their opinions.
Conclusions: The gaming community differentiates between potential performance enhancers based on how problematic they are for the esports scene, with the most concern surrounding hard drugs, pharmaceuticals, and brain stimulation interventions. Participants who are more invested in competitive gaming tend to be more sceptical of enhancers and express greater concerns. Four themes were identified in the thematic analysis: (1) risk, (2) morality, (3) enhancer effects, and (4) regulation. To increase acceptance and perceived legitimacy in decision-making, it is recommended that regulators engage a variety of stakeholders in transparent decision-making processes when forming tournament rules and regulations. This will help address the fragmented regulatory landscape and prevent potential differences in the perception of tournament winners based on the governing body supervising the competition.

KEYWORDS
esports, performance enhancement, fairness, doping, games, culture

Highlights

- The esports community has fairness concerns around the use of drugs, pharmaceuticals, and brain stimulation interventions.
- Enhancers that are encountered in everyday life (e.g., caffeine) are of limited concern.
- Esports regulators should engage in transparent decision-making processes when forming rules and regulation

1 Introduction

Our sense of "fairness" pervades every facet of society—we all hope to be treated fairly. A tension arises in that fairness is intrinsically subjective; perceptions of what is and isn't fair take into account a variety of circumstances, contexts, personal convictions, and cultural norms. This can give rise to conflicts in ideals. Discussions around fairness are typically predicated upon an individual or group having a perceived unfair advantage. Further, whether or not someone perceives an action as fair influences their willingness to take that action. This can have meaningful consequences, both in terms of out-competing vulnerable groups, and engaging in potentially harmful behaviours in order to confer an advantage. As such, understanding community perspectives around fairness is critically important for maintaining community standards and establishing effective regulations to keep people safe. Fairness is of special importance in the context of competition, such as in sports. The protection of fairness in professional sports has led to the creation of institutions such as the World Anti-Doping Agency (WADA), whose mission statement expresses that they seek to "protect the spirit of the sport"—and that "drug-enhanced performance is incompatible with athletic (and human) excellence." The WADA argues that drug regulation is necessary because athletes, in pursuit of achieving optimal performance, are generally more accepting of occupational and medical risk; and, as such, are willing to embrace novel methods of performance enhancement (1–3). Further, the narrow focus on maximising performance can lead to situations in which other individuals are harmed to pursue a specific goal (4).

There are many parallels between traditional sports and esports in terms of fostering a willingness to engage with novel methods of performance enhancement. Popular esports such as League of Legends have between 10 and 11 million daily active users, with over 150 million registered accounts. For professional players to stand out, they are expected to consistently perform at an exceptional standard. Performing at this standard is extremely difficult to achieve and maintain, as the competition is fierce and the stakes are high. In addition to large sponsorship deals, there are increasingly large prize pools for many esports tournaments—for example, in 2021, The International (the biggest Dota 2 tournament) had a prize pool of $40M (5). Outside of the competitive pressure of the tournament context, there is also pressure to perform from many sources, such as team owners, coaches, sponsors, stream viewers, fans, and the esports community at large. With such high stakes, this performance pressure creates an environment in which players may be motivated to embrace novel methods of performance enhancement.

Among the esports community, there is a perception that players are willing to use or consume substances that may enhance performance (6)—especially caffeine and pharmaceutical stimulants like Adderall™. This perception has been reinforced by examples of professional players that have publicly disclosed stimulant use for performance enhancement in tournaments (7), as well as professional players who have more generally claimed widespread consumption of stimulants at the professional level (8). Many esports tournaments are also sponsored by energy drink companies, where advertisements imply that there are performance-enhancing effects from consuming their products. While there are many medical risks associated with the use of stimulants as performance-enhancing drugs (9–11), the presence of performance-enhancing drugs in the esports context also raises questions around fairness and integrity. If some players are using performance-enhancing drugs while others are not, it may create an inequitable and uneven playing ground that undermines the spirit of fair competition. The esports community's perception of fairness will likely play a major role in determining the severity and extent of performance enhancement regulation within the industry.

While drug regulation and performance enhancement in primarily physical sports (e.g., tennis, cycling or weightlifting) have been the target of discussion, debate, and academic inquiry for decades (12–14), the problem remains novel in the context of esports. This problem is compounded by the fact that only a few studies exist that systematically investigate these types of performance enhancement in esports. As the popularity, perceived legitimacy, and financial investment into esports rises, so does the communal need to understand what is fair—and at what point a practice becomes unfair—in esports play. Some practices, such as installing third-party software to enhance in-game performance (e.g., aim assistance in first-person shooters), are generally considered unfair in competitive contexts (15). However, other cases are less clear cut—especially in regards to food supplements, drugs, pharmaceuticals, and even non-invasive brain stimulation technologies. It should be noted that there is a semantically important difference between enhancement and doping: While enhancement is a general term referring to any method by which performance can be increased, doping is more specific in that it commonly refers to the use of forbidden substances (e.g., pharmaceuticals) to maximize performance. Thus while for example the use of mental training, food supplements and biofeedback may all be performance enhancement, the use of anabolic steroids may be considered doping if forbidden by the sport association.

Due to the absence of universal and consistent rules and regulations in esports, a lack of industry-wide oversight, and continued discussion and scandals surrounding professional player intake of performance-enhancing substances (16, 17), there is a clear and urgent need to understand perceptions of performance enhancement in the gaming community. Acquiring this knowledge will allow developers and esports regulatory bodies to make informed decisions commensurate with community expectation and perception, and generate insights about esports players' and spectators' own relationships with performance enhancements in digital competitive contexts (18).

1.1 Scope of the paper

To support esports regulation, we need an in-depth understanding of community perspectives on performance enhancement in esports. In this paper, we examine how gamers of varying professionalization levels rationalize their opinions about the fairness, ethics, and regulation of enhancer usage in esports. We determined the extent to which gaming communities perceive enhancer usage as fair, and explore what kind of regulations community members propose based on their concerns about performance enhancers. We discuss whether or not current practices are sufficient from an ethical and regulatory perspective to appropriately deal with increasing enhancer usage. The fragmented regulatory landscape in esports may lead to a different perception of tournament winners based on which governing body supervised the competition, and this in turn may affect the perceived legitimacy of the sport as a whole. To guide more specific recommendations, we also examined whether or not perception differs based on the background of the players (e.g., esports athletes vs. casual players and viewers), as well as the type of enhancer.

To guide our investigation, we defined and answered the following set of research questions:

- RQ1: How do game communities perceive fairness of performance enhancers in esports?
    - RQ1a: How fair do players consider performance enhancers in esports? Does this judgement depend on the enhancer?
    - RQ1b: How concerned are players about the current state of ethics and regulation of performance enhancers in esports? Does this judgement depend on the enhancer?
    - RQ1c: Are there differences in perceived concerns and fairness between different types of players?
- RQ2: How do players rationalize their opinions about fairness, ethics, and regulations of performance enhancers in esports?

To answer these questions, we conducted a mixed-methods study. We presented several reddit communities with a survey asking a combination of open and closed questions. We leverage the innate pseudonymity of reddit's forums, affording users a sense of privacy, and the online disinhibition effect (19), ultimately hoping to gather honest responses that are not affected by social desirability biases (20). The primary contribution of this work is an overview of community sentiment surrounding the fairness of performance enhancement in esports. Further, recommendations for esports organizations and regulators are discussed.

2 Background

Our research is grounded in prior work on regulations, justice, and legitimacy. In this section, we discuss regulations against cheating, as well as the challenges with enforcing regulations; models and facets of justice; and legitimacy and its relations to injustice.

2.1 Enhancer effects and regulatory challenges

Regulations in traditional sports are largely based on the need to maintain competition fairness. However, in some situations the perception of fairness is inherently subjective. In a game itself rules are ideally set out clearly from the start and as long as everybody adheres to those rules, the game would be considered fair. However, regular discussions about the interpretation or the fairness of rules emerge, highlighting the need for a referee. In sports involving physical contact such as judo or rugby some rules exist to ensure the bodily wellbeing of athletes. In esports the physical wellbeing of athletes typically is not a risk and altercations on the pitch less of a concern. In the context of regulating esports, it is critical to understand why people play esports—and, further, why should they play “fair"? Motivations for professional-level athletes (e.g., the pursuit of fame, fun, financial incentives) may not be related to the reason why a professional player of any (e)sport adheres to certain rules and regulations. Further, the impact of regulations may extend beyond the competition—affecting preparatory training and the private lives of athletes, as well as lifestyle choices (21, 22). Recently, amateur athletes have been in the focus of anti-doping studies and interventions. Amateur athletes lack the medical support team that can mitigate the risk of using certain drugs to enhance performance and a harm-reduction approach may be needed to dis-incentivize or at least reduce the negative health-related outcomes of enhancer usage (23–25) Moreover, regulation itself is often problematic: for example, by stating which specific drugs are prohibited, slightly modified substances may circumvent a ban. In turn, competitors may seek out the consumption of new—and potentially unsafe—drugs that have not yet been prohibited (12, 26). Further, opaque regulations allow for arbitrary judgements that may be influenced by personal biases (e.g., favouritism).For pharmaceuticals and other drugs, it is critically important to consider the varying effects between individuals. For example, the effect of one medication may differ depending on the underlying hormonal profile of a competitor—and so, sensible regulation must be guided by a strong scientific base, and regulatory bodies should consist of a diverse group of individuals (12, 27).

Finally, an additional complexity in regulation is that of medical exemption. Some athletes may require certain medication to deal with an underlying medical problem (e.g., the use of amphetamine salt compounds like Adderall to manage the symptoms of ADHD). However, evidence from Olympic sports shows that both approving and denying a medical use exemption has its issues such as the undertreatment of athletes with medical issues (e.g., ADHD) (28–30). Athletes with asthma are an intriguing example. It is perceived in multiple sports communities that the intake of asthma medication may enhance performance, which leads to a negative perception of athletes with a corresponding therapeutic use exemption for their inhaler (31). Consequently, athletes that may actually need an inhaler refuse therapy in order to avoid being stigmatized. Thus there is a urgent need to change the perception among the athletes with regards to asthma medication, to maintain respiratory health (32). It is possible that athletes may falsely report their symptoms to get access to medically unnecessary prescriptions, and an unjustified medical use exemption. This is especially easy in the context of telehealth—there are websites that are specifically designed to allow people to receive an ADHD diagnosis based on their answers to a standardized test, where scores to receive a diagnosis have been publicly posted online. On the other hand, if a legitimate medical exemption is denied for reasons such as favoritism, the accessibility and integrity of the sport come into question. An ethical tension arises in that allowing people with a legitimate medical use case to compete is important from an access and equity lens, yet this opens a loophole that may promote potentially harmful behavior in players willing to take medical risks.

Thus, it is difficult to create a perfect regulatory framework. Although the WADA has long been the key player in policing illegal performance enhancement, in 2020 the United States of America have singed the Rodchenkov-Act into law, which allows the USA to pursue organizations and athletes involved in doping even outside national borders and charge them with criminal offences (House Bill 835, Public Law No. 116-206). Essentially, with this new self-empowerment the USA is grabbing power from the WADA and creates a second anti-doping policy leader, but the specific consequences of this action remain to be observed (33). Regardless of who holds the regulatory power, regulators need to rely, at least in part, on athletes' own moral conduct. However, previous research has demonstrated that at least 10% of surveyed athletes in traditional sports admit to cheating via doping (13, 34); when considering the potential influence of social desirability bias on self-report responses, the actual usage rate may be even higher. Recently Gleaves and colleagues reviewed literature from 1975 to 2021 about the prevalence of doping in competitive sports (35). When considering only, in their view, high-quality studies 50% report below 5% prevalence rates, 30% between 5%–20% and 20% of studies 30% or higher prevalence ratings. Motivations for cheating are often driven by financial and fame-oriented desires: for example, one study revealed that the temptation to cheat is predicted by a lack of self-control, high impulsivity, and a desire to get rich, as well as social and moral values of the individual (36). A desire for financial gain appears directly predictive of cheating behavior—especially in private situations where the individual thinks they are not supervised. Similarly, Charness and colleagues showed that cheating behavior in the absence of financial incentives was reduced (37). These results are in line with a recent meta-analysis on the topic (18).

2.2 Models and facets of justice

When trying to resolve ethical tensions, it is important to consider the concept of justice. The perception of justice is inherently subjective and often moderated by the role of the stakeholders involved. As such, the concept of justice is multidimensional and subject to a variety of perspectives (38, 39). In the context of fairness in esports, there are four important aspects to consider: first, distributive justice describes the fair allocation of resources; second, procedural justice describes the procedures by which a resource is distributed; third, interpersonal justice refers to an individual's (e.g., an employer or judge) perception of fair treatment of another person (e.g., an employee or defendant); and fourth, informational justice describes clear, transparent, and needs-oriented communication. For example, in a competition format, a specific rule might not be communicated clearly to all teams (informational injustice), or an official may be more lenient towards one team compared to another (interpersonal injustice). Consequently, the process of determining the winner of a competition may be called into question (procedural injustice), and it may be perceived that a winning team won undeservedly (distributive injustice).

2.3 Legitimacy and its relation to (in)justice

According to Tyler's Legitimacy Theory, justice and injustice are tied to the perception of legitimacy (40): the belief that an authority, and its power, is justified. In the context of competition and fairness, a governing body that is perceived to be legitimate is crucial for the adherence to rules and the acceptance of regulatory actions. Research shows that procedural and distributive justice are good predictors of legitimacy (41–44). This connection between perceived fairness and legitimacy is in line with studies of athletes evidencing a desire for the fair, equal, and transparent testing of illicit substances (45). If judges and other officials do not adhere to established procedures, competitors may feel betrayed, which in turn may reduce motivation and future rule adherence. However, people frequently do not have all the information necessary to make a truly objective statement about whether or not an outcome or decision is fair or unfair. Thus, there certainly is a degree of uncertainty involved in most judgements. The Uncertainty Management Theory posits that when information about how to assess fairness is incomplete, individuals will turn to judgements of fairness on other dimensions (46–48). Practically speaking, individuals will use procedural justice judgements to evaluate the fairness of the outcome. A process is perceived as just if all individuals can expect an outcome proportional to their inputs, and that relation is identical across all individuals. Consequently, if an institution can guarantee such subjectively fair procedures, it may be more likely to be perceived as legitimate and morally credible (49).

3 Methods

To answer our primary research questions (RQ1. How do game communities perceive fairness of performance enhancers in esports?; RQ2. How do players rationalize their opinions about fairness, ethics, and regulations of performance enhancers in esports?), we conducted an online survey investigating perceptions of enhancers in esports. This section details our data collection approach, survey instruments, exclusion criteria, and analysis methods.

3.1 Data collection

The survey was advertised on the social news aggregation website reddit, on selected "subreddits" (that is, subforums that cater to particular topics). Moderator approval was acquired prior to advertising and posting on a subreddit, with non-permitted subreddits removed from the pool. In total, the survey was advertised on 27 subreddits between the 1st and 15th of December, 2021. For a complete list of subreddits used, please refer to the Supplementary Material (see https://osf.io/65qzp/). Compensation was offered in the form of an opt-in raffle for one of five $100USD Amazon gift cards. Overall, 664 participants completed the survey. The study has ethical approval from the University of Saskatchewan Ethics Board.

3.2 Instruments

To assess the overall perception of enhancers in esports and participant opinion on the topics of fairness, regulation, and enhancement usage, we employed a combination of closed-ended and open-ended items. Participants provided demographic information (e.g., age and gender), their preferred game genres, and their self-identified "gamer type". The six different gamer types included: (1) full-time professional esports athlete (i.e., esports related earnings make up most of your income), (2) part-time professional esports athlete (i.e., a portion of your income is esports related), (3) amateur esports athlete (i.e., you play in an organized team but earn little to no money with esports), (4) competitive gamer (i.e., you play competitive games regularly), (5) casual gamer (i.e., you do little to no competitive gaming), and (6) speedrunner (e.g., a competitive player that plays the with the intent of completing it as quickly as possible given a certain ruleset). The researchers chose these categories.

For the purpose of the survey, we established five discrete categories of performance enhancers: (1) Food & Food Supplements (e.g., caffeine, Tyrosine, sugar), (2) Pharmaceuticals (e.g., Modafinil, painkillers, benzodiazepines), (3) Drugs that are Commonly Socially Accepted (e.g., alcohol, nicotine, cannabis), (4) Drugs that are Commonly Socially Not Accepted (e.g., psychedelics, opioids), and (5) Non-Invasive Brain Stimulation (e.g., transcranial direct current stimulation)[1]. Participants were provided with a brief description of and introduction to each enhancer category, with examples included for each. Prior to deployment, the survey was piloted internally to ensure ease of understanding and clarity. The survey comprised of five blocks—the first four of which focused on questions concerning the aforementioned performance enhancer categories, and the final block contained open-ended questions concerning fairness, ethics, and regulation[2]. We acknowledge that the classification system presented here is not the sole method for categorizing performance enhancement methods. An alternative system, for instance, might classify performance-enhancing drugs into categories such as stimulants, depressants, cannabinoids, hallucinogens, hypnotics, and dissociatives. However, classifications of this nature introduce unwarranted ambiguities, as seen in instances like both caffeine and methamphetamine falling under the umbrella of stimulants. Further, some of our classifiers were more technical compared to others; Non-Invasive Brain Stimulation for example is a technical term referring to a variety of methods of electrical or magnetic brain stimulation that directly affect nerve cell activity in the brain.

3.2.1 Fairness

The fairness questions were adapted from the Distributive Justice Subscale by Colquitt and colleagues (38, 50). For each enhancer category, participants were asked to respond on a 5-point Likert scale ("definitely not" to "definitely yes") to the question, "If somebody was using [specific performance enhancement category] and was winning a tournament, how would you perceive their success?". The four items to be rated included, "Would the success be reflective of the effort put into the tournament?" (Effort), "Is the success appropriate for the work the player put in?" (Success), "Does the success reflect the individual contribution to the tournament?" (Contribution), and "Would the success be justified given the performance?" (Justified). Based on these items an overall scale score was calculated.

3.2.2 Concerns

For each enhancer group, we asked questions about whether or not participants believed a certain subgroup of performance enhancers should be regulated, or if the use of an enhancer would constitute an unfair advantage. Participants were asked to indicate the degree of how concerned they were from 0 ('definitely not') to 100 ("definitely yes"). This block included four questions: "Would you have any ethical concerns?" (Ethics), "Do you think the usage of this enhancer should be regulated by official esports organizations?" (Regulation), "Would you consider the usage of this enhancer as a form of unfair advantage?" (Cheating), and "Do you think somebody winning in a competition under the influence of this enhancer should be disqualified?" (Disqualified). Based on these items an overall scale score was calculated.

[1]Note that we did not use legality as a classification system. This is because the rules and regulations surrounding different potential enhancers, drugs, and pharmaceuticals can differ drastically between countries. We acknowledge that different categorization systems may influence survey outcomes.

[2]Please note that we collected additional data in this questionnaire. However, these data are beyond the scope of the present manuscript and are reported elsewhere. For details, see ([25])

3.2.3 Open questions

After each segment of questions relating to fairness for each enhancer, participants could optionally reply to the following open-ended question: "Is there a context in which you believe the enhancer to be fair or unfair to use?" Further, toward the end of the questionnaire, participants were prompted to reply to the following open-ended questions:

- "Please share your thoughts about the regulatory implications of using different enhancers for gaming purposes in general. Do you think all or only certain enhancers should officially be regulated in esports tournaments?"
- "Please share your thoughts about the fairness or ethical implications of using different enhancers for gaming purposes in general. Would you consider enhancement as an unfair advantage or would that depend on the circumstances or the enhancer used?"
- "Where would you draw the line between fair and unfair advantages gained by the use of enhancers? Could you describe a context in which enhancements are fair use, and a context in which enhancements are unfair?"

3.3 Data collection and reduction

The survey was advertised on selected subreddits (that is, subforums) on the website reddit.com. Prior to advertising on a subreddit, the authors sought approval from subreddit moderators. In total, the survey was advertised on 27 subreddits (for a complete list, refer to the Supplementary Materials https://osf.io/65qzp/) between the 1st and 15th December 2021. All participants could opt into a raffle to win one of five $100 USD Amazon gift cards. Overall, 664 participants completed the questionnaire Suspected inauthentic data were excluded from further analysis based on the following criteria: (a) average time to completion was below 1.5 s per question, not including the optional open-ended questions, (b) implausible data entry, (c) duplicate replies, indicative of bot or script usage. Based on these criteria, 98 participants were removed from the sample.

3.4 Analysis procedure

3.4.1 Quantitative questionnaire data

The analysis of the questionnaire data involved two phases. First, the quantitative questionnaire data (i.e., responses to the closed questions) were analyzed in order to characterize the sample and find differences between different self-reported gamer types with regard to their level of competitive professionalism. However, due to the unequal group sizes based on self-reported type (i.e., fewer professional esports athletes compared to casual players) complicating an interpretation of inferential statistical data, we also performed a cluster analysis, with the aim to distribute the sample into more homogeneous subgroups. A cluster analysis groups individual datapoints in such a way that data in the same group (i.e., a cluster) is more similar (based on certain input variables) to each other than to those in other clusters.

3.4.2 Qualitative questionnaire data

The open questions asked about the perceptions of fairness specific to enhancer categories, as well as the general perception of regulation and the ethical considerations surrounding enhancer usage. The general analysis procedure for the open questions was the same across questions and followed thematic analysis procedures (51, 52). In the first step, one author generated an initial codebook for the enhancer-specific question of fairness. Second, four of the authors (including the author who generated the initial codebook) each coded 25% of all non-blank replies for that question. Third, to reach a consensus, the authors engaged in discussion throughout the coding process to ensure commensurate understanding. Steps one to three were iterated upon until all authors agreed on the final themes, and their descriptions.

3.5 Positionality statement

All authors possess a background in games user research, and have undertaken previous scholarship in the context of online competitive gaming (and, specifically, the examination of performance enhancement in these spaces). Additionally, all authors possess prior experience playing popular esports titles (such as DotA 2, Counter-Strike, and Player Unknown's Battlegrounds). As such, the authors have examined and interpreted the findings described within this work through the lens of games academics and players, more broadly, and scholars of performance enhancers in games, more specifically.

4 Results

This section details the results of our online survey. To structure the results of our mixed-methods study, we report results in relation to our research questions.

4.1 Demographics

After data filtration, the dataset consisted of 566 individuals (mean age = 25.88, SD = 6.59). The majority of individuals identified as men ($n = 477$), whereas about 12% identified as women ($n = 66$). 11 individuals identified as non-binary, 8 preferred not to disclose their gender and 4 indicated the wish to self-describe the gender they identified with most (e.g., trans woman or genderfluid). Listed in order of frequency, participants indicated the following gamer identity: Competitive gamer ($n = 325$, 57.4%), casual gamer ($n = 121$, 21.4%), amateur athlete ($n = 74$, 13.1%), part-time professional player ($n = 26$, 4.6%), full-time professional player ($n = 12$ 2.1%) and speedrunner (n = 8, 1.4%).

4.2 RQ1a: how fair do players consider performance enhancers in esports? Does this judgement depend on the enhancer?

The reliability of this scale for all enhancers was satisfactory (Cronbach's $\alpha = .90–.95$). The overall fairness score was submitted to an ANOVA with enhancer type as the grouping variable and all F-values were Greenhouse-Geiser corrected due to the violation of the sphericity assumption. Results reveal a significant main effect of enhancer type ($F(3.55, 2003.09) = 123.52$, $p < .001$, $\eta^2 = .18$). Descriptively, pharmaceuticals and not accepted drugs are perceived as least fair, followed by brain stimulation and accepted drugs. Food supplements however were perceived as relatively fair in comparison. For details, see Table 1.

To further disentangle the enhancer-specific effects on fairness perception (see RQ1a), post-hoc analyses were performed using the overall fairness scores. Pairwise comparisons between each enhancer revealed that pharmaceuticals and not accepted drugs were perceived as least fair ($p < .01$ for all other enhancers) and did not significantly differ from each other ($p = .65$). Brain stimulation was perceived as slightly more fair compared to accepted drugs ($p < .05$) and food supplements were considered fairer than all other enhancers ($p < .001$). See Figure 1 for a visual representation of results.

4.3 RQ1b: how concerned are players about the current state of ethics and regulation of performance enhancers in esports? Does this judgement depend on the enhancer?

The reliability of this scale for all enhancers was satisfactory (Cronbach's $\alpha = .83–.90$). To test for differences in concerns about enhancers, we performed a one-way ANOVA with enhancer type as the independent variable. Since the sphericity assumption was violated, all statistics were Greenhouse-Geiser corrected. Results reveal a significant main effect of enhancer type ($F(3.54, 2000.07) = 257.84$, $p < .001$, $\eta^2 = .31$). Descriptively, participants are most concerned about pharmaceuticals, not accepted drugs, and brain stimulation, and least concerned about food supplements. For details see the descriptive statistics see Table 2.

To further disentangle the results of RQ1b, post-hoc analyses were performed on the overall scale score. Pairwise comparisons between each enhancer revealed that pharmaceuticals, brain stimulation, and not accepted drugs were most concerning (all $p < .001$ compared to other enhancers) and did not differ from each other (p-values between.12 and.72). The concern for accepted drugs did differ from food supplements ($p < .001$). For a visual representation see Figure 2.

4.4 RQ1c: are there differences in perceived concerns and fairness between different types of players?

Based on the results from RQ1a and RQ1b (see Figures 1, 2) it seems that, descriptively, different groups of gamers (as indicated through the self-disclosed gamer identity) differ in perceived fairness and concerns about enhancers. In general, the more dedicated a player might be, the more concerned about enhancers they might be and the less fair they perceive them. Specifically, full-time professionals, amateur athletes, and speedrunners seem to be most concerned about enhancers—whereas casual and competitive gamers are less concerned. First, we correlated the scores from the subjective concerns and fairness questionnaires. Results reveal significant negative correlations of concerns for enhancers and fairness; brain stimulation ($r = -.54$, $p < .001$), accepted drugs ($r = -.59$, $p < .001$), not accepted drugs ($r = -.62$, $p < .001$), pharmaceuticals ($r = -.58$, $p < .001$), and food supplements ($r = -.51$, $p < .001$). This indicates that the higher the concern for a specific enhancer, the less fair an enhancer is perceived (and vice versa). Second, to further examine our interpretation, we conducted a k-means cluster analysis (2, 53)[3]. The goal is to create clusters that contain homogeneous data points, but are as heterogeneous as possible. Clustering allows the identification of participants that are similar regarding their perceived fairness of and concerns about enhancers. Variables were standardized before the analysis was carried out using the R-packages "cluster" (54) and "factoextra" (55). Based on several heuristics (i.e., best separation of measurement points, scree plot, silhouette method), the optimal number of clusters was determined to be two. For more details refer to the supplemental data (see https://osf.io/65qzp/).

Overall, 232 participants were in Cluster 1 ("tolerate"), characterized by low concern and high perceptions of fairness, and 334 participants in Cluster 2 ("troubled"), characterized by high concern and low perceptions of fairness. The clusters do somewhat correspond to the self-identified gamer identities. Notably, amateur athletes as well as part- and full-time professional players seem to overwhelmingly fall into the second cluster and perceive enhancers as more troubling. This is also true for competitive gamers, but to a lesser degree. Casual gamers as well as speedrunners are equally distributed between the two clusters. Note that the overall sample of speedrunners is low and thus, interpretation may be limited. For details see Table 3.

Based on this clustering process, the two groups, as expected, differ drastically with regard to their scale values (see Table 4).

Figure 3 shows a distribution of values across clusters and questionnaires in a histogram.

In sum, based on these results we can conclude that there is some evidence that players differ in their perceived fairness and concerns based on their player type. Specifically, the more time an individual invests in esports and the more important competitive gaming is to them, the more likely it seems that an individual possesses concerns about the use and fairness of performance enhancers in the context of esports.

[3]Note that the drastically unequal groups sizes in self-identified gamer categories preclude us from conducting standard pairwise comparisons.

TABLE 1 Facets of perceived fairness with regards to different enhancers.

	Food & food supplements	Brain stimulation	Drugs (accepted)	Drugs (not accepted)	Pharma-ceuticals	Question means
Effort	3.97 (1.21)	3.24 (1.21)	3.55 (1.39)	3.03 (1.48)	3.07 (1.30)	3.36 (.95)
Success	3.99 (1.20)	3.16 (1.21)	3.61 (1.37)	2.99 (1.49)	3.03 (1.31)	3.34 (.93)
Contribution	3.96 (1.21)	3.21 (1.17)	3.55 (1.37)	3.03 (1.47)	3.05 (1.31)	3.36 (.94)
Justified	3.98 (1.22)	3.12 (1.23)	3.66 (1.35)	2.97 (1.48)	2.98 (1.31)	3.34 (.95)
Grand average	3.98 (1.12)	3.18 (1.06)	3.59 (1.25)	3.01 (1.38)	3.03 (1.21)	

Participants could rate each enhancer on each facet of concern from 1 (unfair) to 5 (fair). Standard deviations in brackets. Note that the four components together make up the Grand Average, which is indicative of the overall scale value with regard to a specific enhancer.

4.5 RQ2: how do players rationalize their opinions about fairness, ethics, and regulations of performance enhancers in esports?

We employed two lines of questioning in prompting participant perspectives. In one line of questioning, we asked participants about their opinions on performance enhancers in general; in the second, we additionally posed questions about each specific enhancer type. All participants received all questions. The replies to the enhancer-specific questions were analysed in concert with the general questions. The analysis consisted of two parts. First, the responses were coded based on whether the participants considered enhancers fair using the pre-defined codebook (all unfair, all fair, depends on the enhancer, depends on the situation, depends generally). This data was contextualized with additional information from the coding. We report this data in Section 4.5.1. Second, the data was further analyzed in thematic analysis, as described earlier and reported in Section 4.5.2.

4.5.1 Frequency of fairness codes

A similar number of participants generally thought that all enhancers were fair ($n = 25$, 7%) or unfair ($n = 24$, 7%). The vast majority of respondents indicated that whether or not an enhancement is fair or unfair depends on the enhancer ($n = 141$, 41%), the situation ($n = 93$, 27%), or just in general ($n = 37$,11%). For an overview of how participants' assessment of fairness related to additional factors, please refer to Table 5.

4.5.2 Thematic analysis

Through our thematic analysis, we developed a set of four themes that highlight community discussions and perspectives on

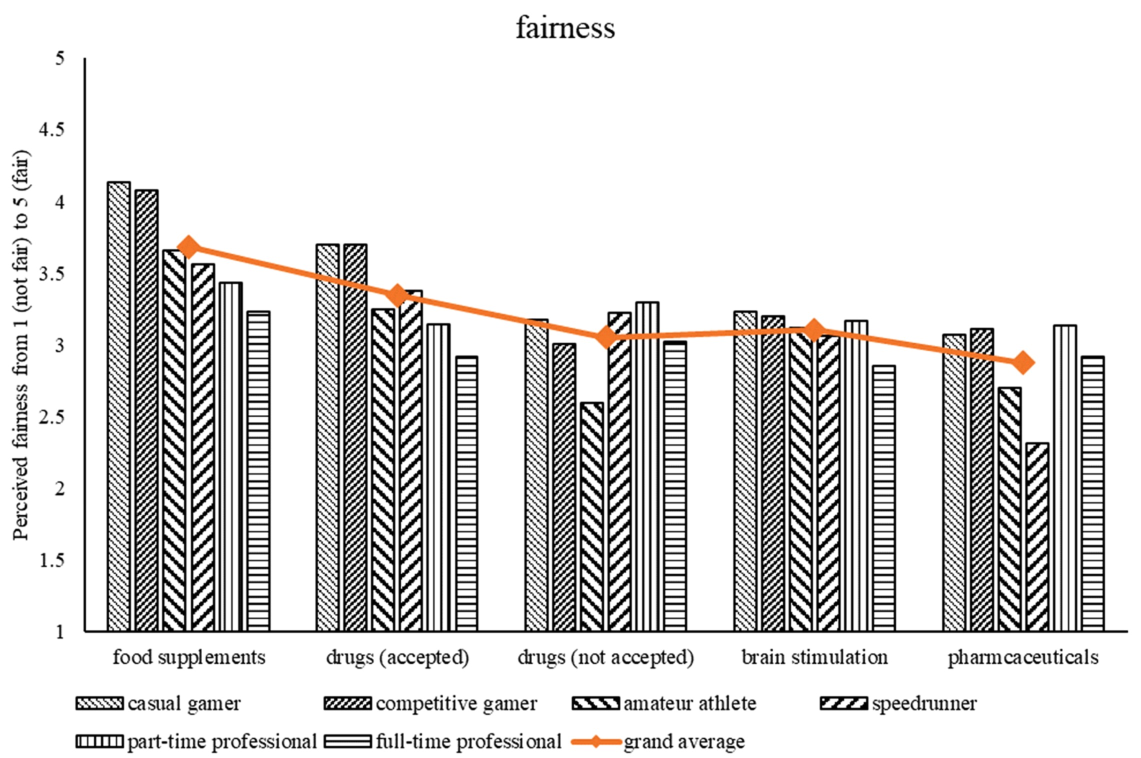

FIGURE 1
Perceived fairness as a function of enhancers and gamer type. Higher values indicate higher perceived fairness.

TABLE 2 Facets of concern with regards to different enhancers.

	Food & food supplements	Brain stimulation	Drugs (accepted)	Drugs (not accepted)	Pharma-ceuticals	Question means
Ethics	23.00 (27.54)	53.92 (33.00)	38.64 (34.45)	67.21 (35.45)	56.22 (33.62)	47.80 (22.72)
Regulation	29.02 (31.75)	65.72 (32.10)	48.53 (36.24)	67.16 (36.19)	63.55 (33.23)	54.80 (23.47)
Cheating	31.04 (31.334)	59.76 (30.73)	33.76 (32.21)	44.15 (36.19)	57.85 (31.63)	45.31 (22.10)
Disqualified	22.48 (28.12)	56.62 (31.44)	36.77 (34.21)	59.29 (36.99)	51.64 (33.28)	45.36 (22.64)
Grand average	26.28 (26.08)	59.00 (26.52)	39.42 (29.41)	59.45 (29.30)	57.31 (28.39)	

Participants could rate each enhancer on each facet of concern from 0 (not concerned) to 100 (definitely concerned). Standard deviations in brackets. Note that the four components together make up the Grand Average, which is indicative of the overall scale value with regard to a specific enhancer.

the fairness of performance enhancers in esports. Some of the themes are somewhat contradictory, as the themes highlight a diversity of opinions around the fairness of performance enhancers, as well as a tension between the impact of enhancer usage on health and competitive integrity.

4.5.2.1 Regulate enhancer use to derisk esports

Many participants felt that enhancer usage created risks for esports, and that increased regulation may be a valid approach to negating some of those risks. While some participants mentioned specific areas of esports that could be better regulated, there were two broad risk categories that were identified as being primed to benefit from regulation. In particular, people view the health of competitive esports professionals as a significant area of concern that needs to be addressed. There has been growing speculation within the esports community that many professional players may be using performance-enhancing substances in order to establish a competitive advantage (6). Overall, there is an appetite among the community to ensure that the health and wellbeing of players are protected through regulatory efforts. In general, the discourse in the community focused on increased regulation to restrict potentially harmful enhancers, such as pharmaceutical drugs—especially for those without a valid prescription. There was a general belief that existing regulatory efforts in this area have not gone far enough to protect player health and players are aware that abuse by (senior) professional

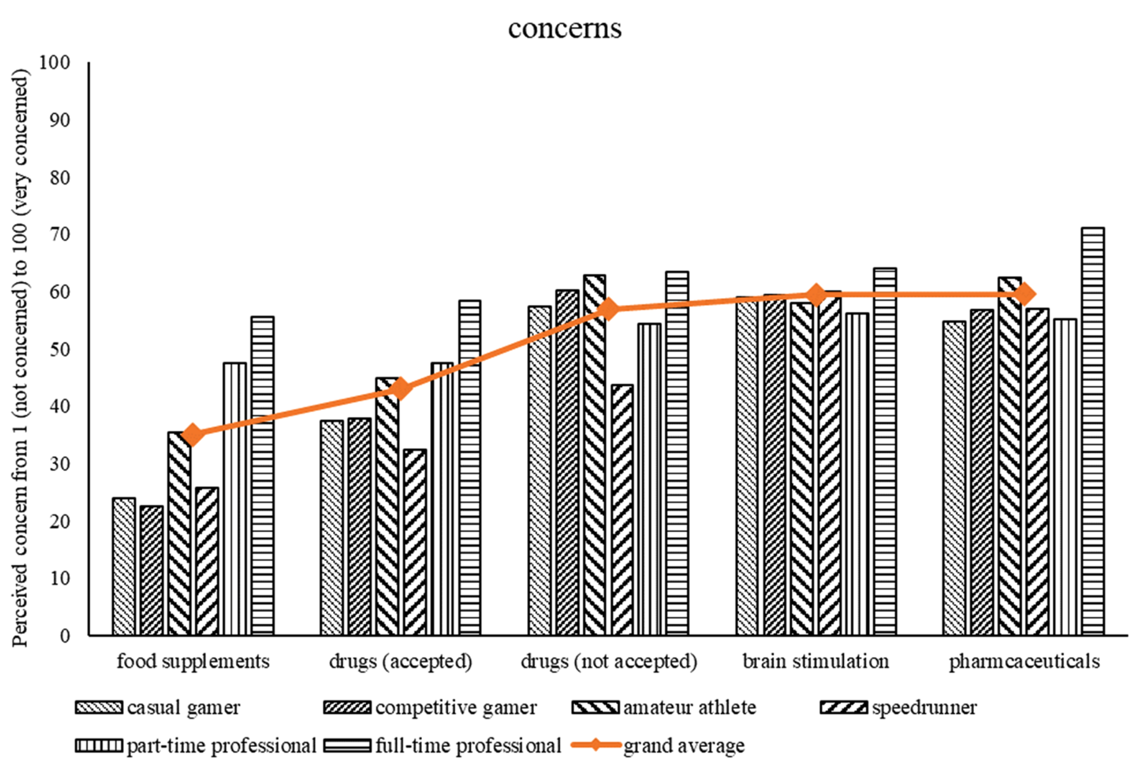

FIGURE 2
Perceived concerns as a function of enhancers and gamer type. Higher values indicate more perceived concern.

TABLE 3 Distribution of participants to one of the two clusters, as a function of their self-described gamer identity.

Gamer Identity	Cluster 1: tolerate	Cluster 2: troubled	χ^2	p
Casual gamers	61	62	0.01	0.93
Competitive gamers	142	183	5.17	.02*
Amateur athletes	18	56	19.51	.00000999***
Part-time professionals	6	20	7.54	.006**
Full-time professionals	1	11	8.33	.001**
Speedrunners	4	4	0	1

All distributions were tested against equal distributions using the χ^2 statistic. A significant χ^2 test implies an unequal distribution of people between the two clusters for any given self-identified gamer type. For example, casual gamers are split 50/50 between the two clusters and thus the χ^2 test is non-significant. However, full-time professionals overwhelmingly fall into the second cluster and thus the χ^2 test is statistically significant. Note that the test outcome can be interpreted with more confidence if the underlying sample is larger.
* = $p < .05$.
** = $p < .01$.
*** = $p < .001$.

players has a knock-on effect on other people in the scene (e.g., "I do see young players potentially copying certain 'habits' of successful players which could lead to future addiction."). Opinions around enhancer use differ substantially, but most people seem to agree that when detrimental health effects occur, it has implications on fairness. "I think enhancers are fine/fair to use in all contexts except for those wherein it is evident that the player is sacrificing an obscene amount of their health and well-being for the result." In a similar vein, people viewed increased regulation as a means to mitigate the risk to the integrity of esports more generally. This group of participants believed that regulation could act as a mechanism to reduce enhancer use, thereby levelling the playing field among competitors (e.g., "I think they would be considered fair game, because brains are unique, and some need help to be on an even playing ground."). There was a particular concern about making sure that everyone was competing on even footing. The majority of participants did not indicate what type of governing body ought to be involved in regulatory efforts—although amongst those that did provide input, there appeared to be a preference for regulation at the esports community level (e.g., regulation within an esports league), rather than governmental regulation. Despite this, some participants did caution against "…delegating regulatory and investigatory authority into regularly officials in a nascent field such as esports." Nevertheless, the legality of an enhancer does not necessarily prevent its accessibility and use: as with other uncontrolled substances, enhancers may be widely available regardless of their legality. To this end, participants noted that "I somewhat see the global legal situation with drugs as being unfair for players. If e.g., player A lives in a country where psychedelic or rather holotropic drugs…are legal/decriminalized and player B lives in a country where psychedelic drugs are illegal…it is obvious that player A might have an advantage over player B.", and, "Unfair advantage is anything that a competitor doesn't have access to that another does."

TABLE 4 Cluster means and descriptive values for questionnaires.

	Cluster 1: tolerate	Cluster 2: troubled
Concerns		
Food supplements	11.07 (15.99)	37.02 (26.46)
Drugs (accepted)	17.24 (18.00)	54.83 (25.73)
Drugs (not accepted)	40.73 (28.74)	72.46 (21.67)
Brain stimulation	46.16 (28.40)	67.93 (20.95)
Pharmaceuticals	44.97 (29.94)	65.89 (23.78)
Fairness		
Food supplements	4.70 (0.59)	3.47 (1.12)
Drugs (accepted)	4.58 (0.63)	2.91 (1.11)
Drugs (not accepted)	4.06 (1.05)	2.27 (1.07)
Brain stimulation	3.84 (0.97)	2.73 (0.87)
Pharmaceuticals	3.62 (1.2)	2.63 (1.03)

SDs in brackets.

4.5.2.2 The only moral enhancement is my enhancement

A relatively large group of participants felt that enhancers have the potential to be unfair or unethical to use, although they generally considered their own use of enhancers to be fair or otherwise justified. For example, people who drink coffee will typically consider enhancers like caffeine to be fair, providing the justification that it only helps players to stay awake—while other enhancers may be unfair because they alter performance. While one interpretation may be that people simply believe that their enhancer usage wasn't that serious, this pattern of response was seen across virtually all enhancer types (e.g., for food supplements "They help, I don't see it being unfair though. I use Gorilla Mind Smooth personally", or alcohol "Whenever I get tilted I tend to grab a bottle of alcohol and get tipsy."). Viewing "other" enhancers as problematic suggests that esports communities will face difficulties reconciling regulation that directly impedes their own enhancer use cases. In a related vein, participants who self-disclosed drug or pharmaceutical usage often highlighted that they were justifiably "leveling the playing field" by mitigating a perceived performance deficiency. Some disclosed conditions such as ADHD, and that prescription stimulants such as Adderall were important to their day-to-day function. In cases where people disclosed having a prescription medication, they almost always advocated that prescription use ought to be exempt from any regulations in the context of esports. Participants who did not disclose that they had a prescription instead made health-related arguments, such as that if they were to cease using opiates they would not be able to play.

4.5.2.3 The fairness of use depends on the enhancer and its effects

Many participants felt that the performance-enhancing effects of the enhancer should be a factor in whether or not they are considered fair or unfair. Some participants understandably felt that there is a relatively large gap in effect between a food stimulant like coffee and a pharmaceutical stimulant like Adderall, and also consider the relative availability of these substances in their consideration: "To me, it is fair as long as the

FIGURE 3
Perceived fairness of and concerns for enhancers as a function of the cluster. The y-axis indicates the number of times this value was chosen as a reply.

stimulant is socially normalized and widely available. Caffeine, alcohol, weed, etc. Whereas, if someone is taking heroin or using electronic brain stimulation devices, that to me is suspect." Interestingly, it is worth noting that the social normalization of enhancers varies culturally—while alcohol and marijuana are normalized to varying extents in some cultures (e.g., The Netherlands), their use may be either illegal, heavily regulated, or socially dissuaded in others (e.g., The United Arab Emirates). As such, the use of social normalization as a yardstick would also represent significant complexity in its application. In many cases, participants perceive it as appropriate to regulate enhancers (especially pharmaceutical and drug stimulants) based on their perceived enhancement effect. In terms of where to draw the line, participants also suggested that enhancers that have a proven performance benefit should be regulated, while enhancers that do not have a proven performance effect should be unregulated. As a caveat, participants with this view often expressed that the magnitude of the effect should also be a consideration, such that household enhancers like caffeine should not be regulated. Although in principle, regulating based on effect seems sensible, in reality, this is problematic as inter-individual differences in responses to enhancers are large. This kind of regulation would necessitate further research into enhancer effects. Participants often view "levelling the playing field" as a legitimate use of enhancers: "I think it is fair to use substances that aren't actually performance enhancing, or to address medical issues you have to make your performance "normal" (e.g., Ritalin for ADHD)". This has interesting

TABLE 5 Participants were asked to indicate in what context enhancement may be considered fair or unfair to use.

Primary classifiers	All unfair	All fair	Depends on the enhancer	Depends on the situation	Depends generally
Additional classifiers					
Legality/against rules	1	3	27	13	9
Availability	1	1	27	14	8
Treat it the same as real sports	0	1	0	1	1
Only when performance is really enhanced	0	1	53	19	19
Only when medically necessary	2	1	31	44	9
Side effects on health	0	2	17	9	11
Only in tournaments/high level play	0	0	5	9	2
Only food/accepted drugs/natural	0	0	47	7	0

The table displays the frequency of replies that fell into certain categories. Additional classifiers were used to further describe the responses; for example, a person may state it depends on the enhancer in question, and clarify in addition that they would be fine with people using pharmaceuticals only for medical reasons. Consequently, the secondary classifiers give nuance to the primary meaning of a response to the question. Note that one response may be coded with more than one additional classifier.

implications for prescription drug abuses, as it highlights that the community has strong values around supporting people with legitimate medical needs.

4.5.2.4 Regulation is not a simple solution

Some people also felt that efforts to increase fairness through regulation would be difficult, and potentially even detrimental. At large, participants with this perspective seem to believe that non-medical use of prescription medications ought to be regulated. However, it seems unclear which enhancers should be regulated and who makes the decisions; some players even suggest a player-driven process to decide what is regulated on a game-by-game basis (e.g., "Needs to be even playing field for both sides. Could ask other side if it's acceptable to be fair.") Further, they see the system for determining medical necessity as flawed. In particular, there were concerns raised that players can simply "doctor shop" to obtain prescriptions. This phenomenon creates a major barrier to regulation, in that regulators either need to exclude people who have a legitimate medical need, or open the door to non-medical use of prescription medications (e.g., "When it comes to Adderall it should be unfair to use if it's not prescribed and it should be highly regulated that the people using it with a prescription are using it in a fair manner. e.g., prescription being forged, they're not supplying it to other players/teams etc."). Participants highlighted that this is further complicated by the jurisdictional availability of pharmaceuticals in different regions. This is especially interesting in the case of online tournaments, where competitors may be competing remotely from countries with different legal frameworks. In a similar vein, people also raised concerns about triggering a "substance arms race", in which players willing to use enhancers may attempt to game the system, and take dangerous experimental substances in order to skirt restrictions around specific pharmaceuticals. This concern appears to stem from other sports (e.g., "If you regulate amphetamines + modafinil, teams will be bribing doctors to get their players diagnosed with adhd and they will get medical prescriptions. It will lead to untestable versions being developed and teams will get barred from playing like russia at the olympics."). Some voices in the community even argue that any regulation outlawing certain enhancers would be counterproductive (e.g., "Almost all elite athletes use performance enhancers already, even if banned. Elite athletes will do anything to win, even if it shortens their life. Instead of keeping it as an open secret, just allow everything unrestricted, so long as the athlete themselves is the one doing the competing.") and that drug testing itself can be a problematic endeavour (e.g., "Regulation with drug testing is useless. The test will become to easy to manipulate but allowing a certain amount and limit extreme doses can give a little but not a lot."). There was also general consensus that regulation should not attempt to interfere with casual play, and should only exist for high-level, presumably professional esports: "You can dope yourself in semi-casual ladder gaming, when only virtual numbers of rating on the line. Other than that it's a no go".

5 Discussion

In this section, we summarize the results of our analyses and discuss the implications with regard to the extant literature, and future regulatory efforts.

In short, our results reveal that the esports community at large is more concerned with pharmaceuticals, non-invasive brain stimulation, and socially non-accepted drugs as compared to food supplements or socially accepted drugs (vice versa for the perception of fairness). Further, the community can be divided into two clusters: those troubled by enhancer usage and those tolerant of enhancer usage. Investigation into the clusters reveals that the more time an individual invests in esports and the more important competitive gaming is to them, the more likely it seems that an individual possesses concerns about the use and fairness of performance enhancers in the context of esports. Additionally, a thematic analysis revealed four discussion themes present in the esports community: that enhancers should be regulated to derisk esports; that personal enhancement usage is typically justified by the individual; that fairness is dependent on the enhancer, as well as its effects; and that regulation is complex and multi-faceted.

5.1 Fairness by enhancer

With regards to fairness and concerns, participants agreed that pharmaceuticals, brain stimulation, and not socially accepted drugs were similarly both highly concerning and least fair. For comparison, the concern was twice to thrice as high as compared to food supplements and socially accepted drugs. The difference was less pronounced in the fairness ratings, but even there a difference of 20% is observed.

5.2 Players' thoughts about fairness and concerns

Dedication to a game seems to impact the perception of enhancers and generally speaking: more dedicated players were more concerned about enhancers and perceive them as less fair. These results support the notion that the higher the degree of importance for competitive gaming in an individual's life, the more likely they will be troubled by the possibilities of illegitimate enhancement methods. We suggest that there are multiple potential factors that may explain this distinction: first, that the more important a role competitive gaming play in an individual's life, the higher the regard they have for the sanctity of the format (that is, that these players are less likely to perceive competitive gaming as "just a game"). Secondly, these players may be more likely to expect that they may eventually compete against players with an enhanced advantage (or, conversely, be in a position in which they may feel compelled to employ enhancers). Third, said players may already have negative personal experiences with enhancers in competitive formats (regardless of disclosure). We note that many player discussions have centered around the topic of equal opportunities in a competition, so that winning is determined by skill and not affected by other factors. Thus, although the players don't use the term, justice is important (38). Community members' voices echo the notion that distributive justice can only be achieved if transparent procedures are in place to ensure that the competition outcome is based on skill rather than for example access to resources such as performance enhancers or bribes for judges. Put differently, if access to and restrictions of performance enhancers are not equal for everybody and based on the same set of rules, any outcome of a competition can be questioned.

In the end, these results are comparable to results obtained investigating fairness perception in more traditional sports [e.g., (12, 29, 49, 56)]. Thus there seems to be a shared commitment to "fair play" emphasizing the universal values of sportsmanship, discipline, and healthy competition, transcending the boundaries between virtual and physical sports. This not only upholds the integrity of competition but also promotes a sense of equity among athletes and fans alike. The "Spirit of Sport" can be preserved by making sure the perception of fairness is held high and that the will to succeed does not lead to circumvention of rules and the use of illicit performance enhancers (57, 58).

5.3 Regulatory implications

The results make it clear the regulators and other stakeholders in the esports industry need to consider how to go forward. One such issue that needs to be addressed in the future is the use or abuse of pharmaceuticals. If regulators decided to ban the use of pharmaceuticals that are not medically needed, a well-known problem emerges. Although in theory, the 'therapeutic use exemption' should only affect people that actually need a certain pharmaceutical to overcome a limitation, in reality, people will find a way to gain access to that exemption via illegitimate means (e.g., bribery, forgery) or circumvent the drug-screening process (12). Thus a harder regulatory stance may be taken, but that may also lead to wrongful denial of medication. There have been cases where athletes even removed themselves from competition after a therapeutic use exemption was denied (28). Thus anything that would be considered typically as doping (such as abusing pharmaceuticals beyond the therapeutic use exemption) is, ethically speaking, discouraged as it undermines the "spirit of the sport" as the WADA puts it. However, there is also a problem with supposedly ethical performance enhancement that seeks only to optimize performance through transparent and acceptable means, contributing positively to the perceived fairness of sports. Where do the boundaries between doping and ethical performance enhancement lie? Who makes those rules? Is it ethical when only a portion of the athletes have access to legitimate performance enhancement due to for example high-costs? Striking a balance between pushing the boundaries of human potential and maintaining the integrity of fair competition—also in the eyes of the outside observer—is tremendously difficult but crucial in navigating the ethical landscape of sports performance.

Further, regulators should remain cognizant of positioning esports as an inclusive and equitable space. While esports does currently pose significant barriers to participation from marginalised groups [e.g., the presence of discriminatory behaviours and expectations directed at women; see (59–61)], the medium in which esports occurs erases many of the physiological disparities present in physical sports. As such, regulators should seek to maintain the more equitable advantages of this novel sporting context—and be aware of the potential of regulations and drug testing procedures to discriminate against groups of people. Regulators may turn to other "mind sports", such as chess, for guidance on the matter. The International Chess Federation (FIDE) abides by the general WADA rules and stresses the importance of certain potential stimulants for chess. Specifically, FIDE prohibits the use of stimulants such as pseudoephedrine, amphetamines, ephedrine, and modafinil. Notably, while substances such as caffeine and codeine are not strictly prohibited, they are monitored. However, given the history of doping scandals in WADA regulated sports it seems prudent to assume that some chess players circumvent regulations. Nevertheless, chess may be similar enough to look for inspiration on anti-doping regulations. Although chess may be used as inspiration for regulators, there are distinct differences between chess and esports. Unlike chess, esports places a considerable emphasis on motor skills, expanding the scope of necessary regulations. The dexterity involved in esports present distinctive challenges that go beyond the cognitive demands found in chess. Specifically, in chess, the FIDE prohibits stimulants primarily targeting brain activity. Although similar substances can be problematic in esports as well, the regulatory landscape in esports needs to consider a broader spectrum of performance enhancers, including those targeting direct muscle activity and analgesics to numb pain from carpal tunnel syndrome.

In general, any regulatory effort needs to consider how athletes are treated and what image is projected onto them: are athletes presumed to be innocent or guilty? If an athlete is presumed to be guilty from the beginning, the athlete may decide to conform to those assumptions and break the rules. One way to potentially reduce cheating behavior is to change the way unfair behavior is discussed and how fairness is promoted. For example, Bryan and colleagues (62) showed that people were less likely to cheat when the framing of pro-fairness slogans implies that cheating is diagnostic of an undesirable identity. However, Bryan et al. also point out there are issues with using this approach. First, false positives when detecting cheaters may result in individuals falsely integrating cheating behavior into their identity; second, this approach relies on the fact that the individual sees themselves as a good person, and does not want to cheat. As such, a person that wants to play unfairly will not be affected. A further problem is the perceived fairness of the regulation itself as there is for example a danger of false positives or procedurally unfair procedures leading to a disqualification of athletes (63, 64). For example, recently Sun Yang, a Chinese Olympic-Gold-Medalist in swimming, was banned for several years because it was deemed proven he interfered with a blood sample (65). However, observers and researchers have argued that this trials may not have been fair because of inadequate translation services and the athlete had his right to be hear infringed. The problems with tests themselves are further exacerbated when considering trans athletes and steroid users wanting to return after a suspension (66, 67). Although sex-specific doping or steroids in esports seem to be to a lesser degree concerning in esports, the core issue of subjectively unfair regulations remains.

An additional challenge arises based on the structure of the esports system. Esports is driven by companies with the goal of maximizing profits. Consequently, the health of the athletes as well as the propagation of fair competitions may only be a means to increase profit and not inherently valuable to a company. For example, the gaming and esports market is heavily targeted by energy drink companies, such as "Red Bull". Red Bull sponsors esports teams around the globe and even finances competitions. Although in isolation this may not be problematic, the heightened consumption of energy drinks may not only be problematic for health reasons but undermine anti-doping policies in general (68). Similarly, nootropic manufacturers (e.g., HOLY, LevlUp) or brain stimulation companies (e.g., halo, omnipemf) may soon start sponsoring esports teams to increase their public exposure. All of these potential enhancers have an inherent health risk associated with them, with no guarantee to actually enhance performance in an individual. So the question needs to be asked whether or not a 'potential' enhancer should be regulated or not, and what regulations should apply for "potentially" unhealthy substances. What can be possible concerning is the match between energy drinks as a product and esports, resulting a powerful marketing force (69). Undoubtably high-glucose energy drinks are unhealthy, especially if consumed in larger doses, and they are already marketed towards younger individuals, which overlap with the audience consuming esports content (70). Given that esports itself as well as its regulation is de-centralized and driven by commercial interests of the companies owning the game being played, there is a conflict of interests that may negatively affect the health of both athletes and consumers of the sport (71, 72).

Further, our results revealed a strong community sentiment towards only regulating enhancers that have been proven to increase performance. However, this implies that actual research exists and that the results are conclusive. While for some enhancers, such as cocaine, such research may be unethical, other performance enhancers only improve performance in some individuals. For example, non-invasive brain stimulation via transcranial direct current simulation results in large inter-individual differences (73, 74). As such: while the community sentiment on this subject is largely cohesive (that is, apply regulatory restrictions only to enhancers with a proven enhancement gain), the path towards collecting evidence to support these regulations is fraught, poses ethical concerns, and requires a large body of work. Consequently, regulation reliant on this motivation may currently be hamstrung by a lack of empirical guidance.

Another side-effect of being a company-driven sport is that no overarching governing agency exists that has the power to enforce rules. Whereas in Olympic sports the World Anti-Doping Agency (WADA) possesses significant authority, and most national sports bodies operate within its frameworks, there is no equivalent in the esports scene. The Esports Integrity Coalition (ESIC) is one organization that aims to become a leader in that regard, but other organizations such as the World Esports Association (WESA), which was established by a tournament organizer, the Electronic Sports League (ESL), and the International eSports Federation (IeSF) claim overlapping responsibilities. Currently, each tournament organizer can effectively publish their own set of rules. As a consequence rules across and even within sports (games) may not be consistent, procedures not transparent, and regulations unequally enforced. For example, while League of Legends developer Riot Games holds its own tournaments, the premier organizer of Starcraft tournaments is ESL and not the game developer itself. While within a certain community a specific organization can be viewed as the legitimate governing body, no organization can currently claim legitimacy across esports as a whole. An organization claiming to legitimately govern the whole of esports would need to provide a regulatory ruleset that is perceived to be fair by the majority of the community, but especially the competitors.

5.4 Limitations and future research

While this work makes important contributions to our understanding of enhancer perceptions, the study has several limitations to be mindful of. First, the gender distribution of the sample is skewed towards participants that self-identified as men. This may be an artefact of the community sampling method used. While there is good evidence to support that women comprise approximately half of all gamers, women have been disproportionately underrepresented at professional esport events. Gender discrimination, harassment, and negative stereotype threat are believed to contribute to the lack of women in professional esport contexts (75–77). Future research and governing efforts should aim to further investigate women and non-binary perspectives on esports and foster a welcoming environment for all players. Second, the enhancer categories that participants were presented with could have been structured differently; specifically, the categories could have been more granular. For the purposes of simplicity and keeping the survey short, several broader categories of enhancers were constructed. However, there are many pharmaceuticals or drugs available that may impact the individual in different ways (e.g., stimulants vs. depressants vs. psychedelics). Splitting enhancers into a greater number of categories would have inflated the time to complete the survey drastically. Our approach sought to balance data quality by maintaining participant attention, while offering broader categories. The categorization of performance enhancers utilized in this research is notably broad and lacks specificity concerning sport-related enhancements, which is particularly pertinent in the context of esports. Additionally, the chosen categories may incorporate a degree of bias, as terms like "drugs" carry normative implications. Nevertheless, future studies that focus on pharmaceuticals and drugs only should use a more fine-grained approach. Third, different self- identified gamer types are represented in the sample with varying frequencies. We tried to recruit as many professional players as possible by recruiting from subreddits dedicated to esports or certain esports teams. We were successful in recruiting a good number of professional players (112 individuals, 19.79% of the sample, reported to play at least at an amateur level). Fourth, there are known limitations with self-report measures and questionnaires, such as social desirability biases or tendencies towards the mean. Although we cannot fully exclude these issues, distribution analysis shows reasonable standard deviations (see Tables above) and distribution parameters. Specifically, the interquartile range for enhancer concern (rated from 1 to 100) was between 32 and 48 depending on the enhancer and between 1.5 and 2.2 for fairness perception (rated from 1 to 5). The range of values incorporated both extreme values for each enhancer for both concern and fairness scores. Future research could make use of implicit measures that aim to circumvent potentially problematic self-report issues (78). Fifth, we only added a scale measuring distributive justice, even though other facets are also important. Distributive justice evaluations focus on the outcome of a process, rather than the evaluation of the process itself. Evaluating whether or not a person or team subjectively deserves to win is possible for all participants. However, evaluating the process, the interactions with officials or the flow of information may not be possible for all study participants. Studying other aspects of justice required either the creation and evaluation of vignettes or the focus on people with insider information (e.g., esports professionals). Sixth, justice and injustice as well as their consequences, are potentially difficult to study because experimental manipulations can only be done on a small scale, otherwise, they would be unethical. Thus researchers rely on the creation of vignettes, questionnaires, interviews, and the post-hoc evaluation of certain events. Nevertheless, these subjective perceptions are real and shape behavior, even if they are not necessarily routed in facts.

6 Conclusion

This work investigates the perception of performance enhancer usage in esports contexts. Analysing the data both quantitatively and qualitatively, we investigated fairness and concerns surrounding performance enhancer usage as well as the regulatory implications. Results show that the competitive gaming community at large differentiates between potential performance enhancers and is most concerned about "hard" drugs, pharmaceuticals as well as brain stimulation interventions (vice versa for fairness judgements). Socially accepted drugs and food or food supplements seem to be more accepted. Further, people that are more invested in the competitive gaming scene tend to be more skeptical of performance enhancers and tend to have bigger concerns. Understanding how the competitive gaming community thinks about enhancers can inform future regulations. The fragmented regulatory landscape in esports may lead to a different perception of tournament winners based on which governing body supervised the competition. The perception of fairness of a competition is key to that competition and its outcomes being perceived as legitimate. If an institution (e.g., a tournament organizer) can guarantee a competition that is largely perceived as fair, the organizer as well as the outcome will be more likely to be perceived as legitimate. We suggest that regulators involve researchers as well as their playerbase (e.g., in the form of a community or an esports athlete council) in an transparent decision-making process when it comes to tournament rules and regulations. In turn, a transparent decision-making process may result in a higher acceptance and perceived legitimacy of a decision. The present results further highlight that esports and traditional sports are not that different. In fact, the present finding resonate with traditional sports literature, which may not be surprising given the more recent professionalization of esports and it being picked up by established sports teams (such as Paris Saint-Germain or Schalke04).

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by University of Saskatchewan Research Ethics Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MF: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. MK: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. JF: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. CP: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. RM: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Heartbeats and high scores: esports triggers cardiovascular and autonomic stress response

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Introduction: Gaming is often labeled as sedentary behavior. However, competitive gaming, also known as esports, involves significant cognitive demands and may induce stress. This study aims to investigate whether the psychophysical demands during esports elicit a physiological stress response.
Methods: Fourteen FIFA 21 and thirteen League of Legends players (23.3 ± 2.8 years) were recruited for the study. Heart rate (HR), root mean square of successive differences between normal heartbeats (RMSSD), peripheral and central blood pressure (BP), pulse wave velocity (PWV), and energy expenditure (EE) were assessed during supine rest, seated rest, and competitive FIFA or League of Legends matches.
Results: No significant group × condition interactions were observed for any of the outcomes. However, there were significant increases in mean HR ($p < 0.001$, $\eta_p^2 = 0.383$), RMSSD ($p = 0.019$, $\eta_p^2 = 0.226$), peripheral systolic BP ($p < 0.001$, $\eta_p^2 = 0.588$), peripheral diastolic BP ($p = 0.005$, $\eta_p^2 = 0.272$), central systolic BP ($p = 0.005$; $\eta_p^2 = 0.369$), central diastolic BP ($p = 0.016$, $\eta_p^2 = 0.313$), PWV ($p = 0.004$, $\eta_p^2 = 0.333$), and EE ($p < 0.001$, $\eta_p^2 = 0.721$) during both games compared to the seated rest condition.
Conclusion: Despite the sedentary nature of esports, the psychophysical demands appear to elicit physiological responses. Interestingly, no significant differences were found between the different game genres.

KEYWORDS
esports, mental stress, physical stress, hemodynamics, heart rate variability, energy expenditure

1 Introduction

Esports is an unprecedented cultural phenomenon defined as organized competitive digital gaming played across a spectrum of professionalism, often associated with elements such as spectators, fans, tournaments, leagues, training, skill development, sponsorship, commercial partnerships, and prize money (1). The exponential growth of esports, encompassing both viewership and participation, has raised concerns about the overall well-being of esports athletes (e-athletes) (2, 3). This concern stems from the inherent sedentary nature of video gaming, which has been shown to have detrimental effects on health. Prolonged sitting is associated with an increased risk of developing cardiovascular disease, obesity, and diabetes (4, 5). It is worth noting that sedentary behavior is increasingly recognized as an independent risk factor for adverse health outcomes, regardless of an individual's level of physical activity (4, 6).

Therefore, even though e-athletes may not be physically inactive *per se* (7, 9), extended periods of sedentary gaming could still pose a potential health risk. According to an online survey conducted by Kari et al. (10), e-athletes train for approximately 5.28 h every day throughout the year. Interestingly, most studies on esports define video gaming simply as sitting and primarily focus on potential health concerns related to sedentary behavior. However, it is important to recognize that e-athletes are subjected to intense mental and even physical demands while competing (11, 12). In fact, top athletes in esports can make up to 10 actions per second or 500–600 actions per minute (13). Additionally, they must adaptively cope with the cognitive challenges and emotional stress inherent in competitive settings (14, 16). Potential mental stress experienced during extended and repetitive hours of gaming could increase the risk for chronic stress, which is associated with an elevated risk of cardiovascular diseases as well as mood disorders such as depression (17, 18). This prolonged mental stress, coupled with the sedentary behavior inherent in esports, can contribute to the overall health risk of e-athletes.

The physiological stress responses associated with esports have not been thoroughly investigated. The current literature on physiological responses during video gaming indicates that e-athletes experience notable physiological changes during gameplay (19). Studies have observed increases in heart rate (HR), blood pressure, and energy expenditure (EE) during video gaming compared to rest (19). However, the literature is inconclusive, and variations appear to exist depending on the specific game genres (20) and whether the game setting is casual or competitive (19).

Previous research has shown that higher physical fitness can mitigate cardiovascular reactivity in response to acute psychological stressors (21) and physiological stressors (22). Therefore, it is worth questioning whether physical fitness plays a role in the physiological stress response during gaming and whether promoting physical fitness could serve as an effective preventive measure against gaming-induced stress.

This study aims to assess HR, heart rate variability (HRV), blood pressure, and EE duringesports. Furthermore, it seeks to evaluate whether there are differences in physiological reactions with respect to game genre. Lastly, the study aims to investigate the potential influence of physical fitness and match result on the stress response induced by gaming.

The findings of this study will provide valuable insights into the physical stress experienced by e-athletes and its potential implications for their overall health and well-being. These results can inform future research and the development of interventions aimed at enhancing performance and potentially mitigating health risks in this population.

2 Methods

2.1 Participants

This observational study included a sample of e-athletes who met specific inclusion criteria: (1) were engaged in esports [either FIFA 21 or League of Legends (LoL)], (2) were between the ages of 16 and 45, (3) had no physical limitations that hindered exercise, (4) provided written informed consent, and (5) were not taking antihypertensive or other cardiovascular medication. Participants were recruited through personal contacts and social media platforms (Facebook, discord, Twitter). The recruitment and data collection period spanned from January 2022 to September 2022.

An *a priori* power analysis was conducted using G*Power (Version 3.1.2; Heinrich Heine Universität, Dusseldorf, Germany). Based on an assumed large effect size (23) and an alpha level of.05, a minimum of 16 participants was deemed necessary to achieve an appropriate power of 0.8. Using these estimated sample sizes, our proposed sample of 27 participants (FIFA = 14, LoL = 13) was more than adequate. Prior to enrollment, the participants were provided with information regarding the study's objectives and procedures, and written consent was obtained from each participant.

2.2 Study design

The study took place at the health physiology laboratory of the University of Bern. Participants visited the lab on two separate test days, with a minimum of 48 h between each visit. They were instructed to arrive at the lab at least 4 h after their last meal and to avoid consuming caffeinated or alcoholic beverages, as well as nicotine, for 4 h prior to their visit. Additionally, they were advised not to engage in intense physical activity for at least 24 h before each test day. The experimental procedures of the study were approved by the Ethical Commission of the Faculty of Human Sciences at the University of Bern (Nr. 2021-02-00005).

2.3 Procedure

During the first test day, anthropometric parameters and demographic data were collected. Moreover, an incremental exercise test was conducted to determine rate of peak oxygen consumption (VO_2peak) and peak HR (HRpeak).

On the second test day, resting EE was assessed using indirect calorimetry. During the last 5 min of the EE assessment, HR and HRV measurements were obtained. Subsequently, hemodynamic parameters were assessed (Figure 1).

Participants then transitioned to a seated position, where EE, HR, and HRV were measured again during a 10-min period. Participants sat on a chair and were instructed to remain calm, recline slightly, and ensure that their feet were flat on the floor, with arms resting on the upper thighs. The use of entertainment media was not allowed. Following this, hemodynamic parameters were recorded. Finally, EE, HR, and HRV were measured during a competitive game of either FIFA 21 or LoL (Figure 2). Hemodynamic parameters were assessed directly after the gaming session (Figure 1). Trained study staff conducted all measurements using standardized procedures and the same equipment. The temperature of the lab was controlled at 20 ± 1°C.

2.4 Gaming session

The FIFA e-athletes engaged in a game of FIFA 21 (Electronic Arts, Redwood City, USA) on the PlayStation 4 (Sony, Tokyo, Japan). FIFA 21 is a soccer simulation and the most popular

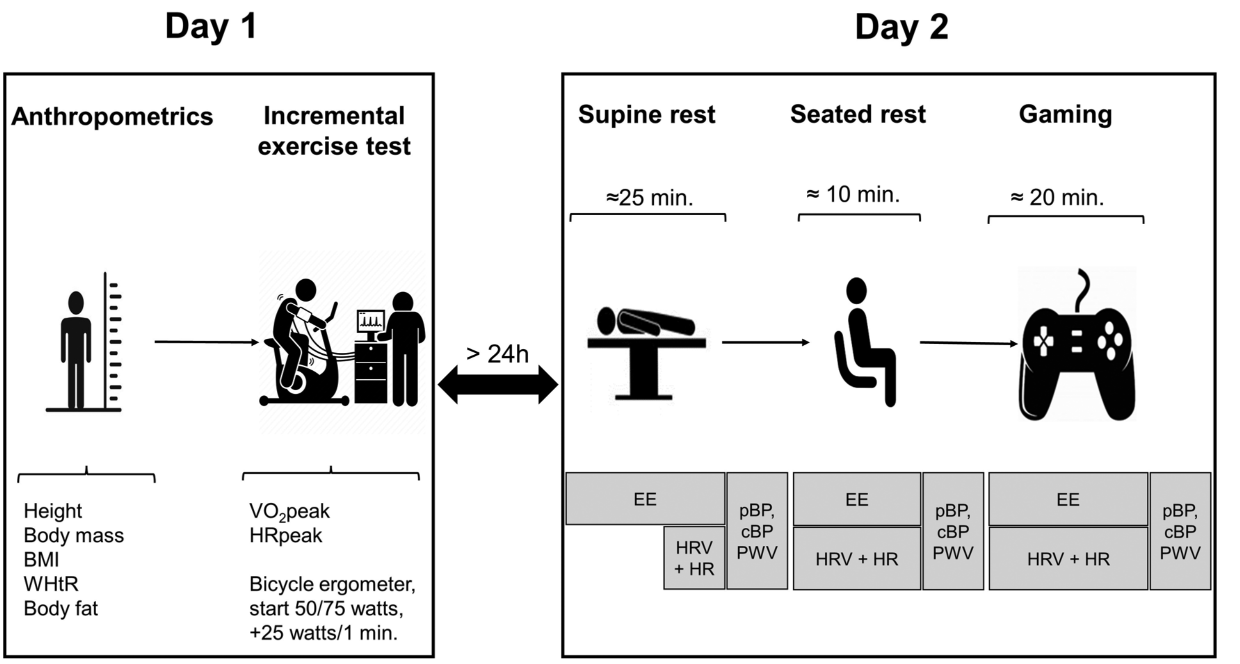

FIGURE 1
Study design. BMI, body mass index; WHtR, waist-to-height ratio; VO_2peak, peak oxygen consumption; HRpeak, peak heart rate; EE, energy expenditure; HR, heart rate; HRV, heart rate variability; pBP, peripheral blood pressure; cBP, central blood pressure; PWV, pulse wave velocity.

FIGURE 2
Setup of the gaming session.

single-player (1 vs. 1) game in the sports genre. The game allows players to control virtual soccer teams and participate in matches. The gameplay involves strategic decision-making, passing, shooting, and defending. Given that FIFA 21 is a single-player game, individual performance is directly linked to match outcomes. While FIFA can be played on PC, it is more commonly played on consoles such as the Xbox and PlayStation, with the gamepad being the most frequently utilized control device. To maintain a competitive environment in the present study, the e-athletes participated in an online seasonal competition called "FIFA 2021 Ultimate Team Champions - Division Rivals". This competition utilizes a skill-based ranking system to ensure fair matchups. The game was played on a PlayStation 4 (Sony, Tokyo, Japan), where e-athletes either used their own controllers or were provided with a DualShock 4 Wireless Controller (Sony, Tokyo, Japan).

Regarding the LoL e-athletes, they took part in a game of LoL. LoL is a highly popular and complex multiplayer online battle arena (MOBA) video game developed by Riot Games (Riot Games, Los Angeles, USA). In LoL, two teams of five players each compete with the objective of destroying the opposing team's Nexus, a core building located within their base. Each player controls only one character from a bird's-eye view perspective. Players select champions with unique abilities, forming a team composition to complement each other's strengths and exploit the opponent's weaknesses. Due to the team-based nature of the game, individual performance of a player may not necessarily ensure overall team success. The game's intricate mechanics, diverse champions, and dynamic map contribute to a challenging environment that demands a diverse set of skills. LoL is played exclusively on PC using a mouse and keyboard. The athletes in the present study played a match within the ranked tier Solo Queue. This game mode matches athletes with others possessing a similar skill level or rank, thus ensuring balanced gameplay experiences. The game was played on a gaming computer (Mifcom GmbH, Munich, Germany). A gaming mouse (Razer DeathAdder Essential, Razer, California, USA), mousepad, keyboard (Sharkoon Skiller SGK4, Sharkoon Technologies GmbHm, Pohlheim, Germany), and monitor (P2719H, Dell Technologies Inc., Round Rock, USA) was provided or the athletes used their own devices.

Both FIFA 21 and League of Legends (LoL) demand distinct skill sets from their players. Nagorsky and Wiemeyer (24) emphasize the significance of personal attitudes, strategic thinking, and decision-making in LoL. In contrast, FIFA places greater emphasis on competencies such as handling technical issues, adjusting game settings, and reaction time. Due to the team-based nature of LoL, teamwork and receptiveness to team feedback are notably more important in LoL (24).

All e-athletes were instructed to use their primary, personal accounts to ensure they were motivated to win. Additionally, all participants that won their game took part at a raffle where they could win prices. Participants were instructed not to engage in verbal communicate during the gaming session. However, impulsive reactions based on what was happening in the game were permitted and did not need to be deliberately suppressed.

2.5 Measurements

2.5.1 Anthropometrics

Height was assessed using a stadiometer. A bioimpedance scale (Tanita RD-545, Tanita Europe BV, Amsterdam, Netherlands) was used to assess weight and calculate body fat. Waist circumference was measured with a precision of 0.1 cm at the midpoint between the iliac crest and the lowest ribs. Body Mass Index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). The Waist-to-Height Ratio (WHtR) was determined by dividing the waist circumference by the height (waist circumference/height).

2.5.2 Incremental exercise test

An incremental exercise test on a bicycle ergometer (Ergometrics 800s, Ergoline GmbH, Bitz, Germany) was conducted to determine individual HRpeak and VO_2peak. The test started at 50 or 75 watts (depending on lean body mass and training status) with a stepwise increment of 25 Watts per minute. Participants performed a five-minute warm-up at the respective starting watt level before proceeding to the incremental exercise test. Participants rode on the bicycle until voluntary exhaustion or until a cadence of greater than 60 revolutions per minute could no longer be maintained. Verbal encouragement was provided by the study staff to ensure participants exerted maximal efforts. The test concluded with a 3-min cool-down at 50 watts.

Throughout the test, oxygen consumption was collected and analyzed. The VO_2peak was calculated as the highest recorded value, using the recorded rolling average of 15-second epochs. HR was monitored throughout the test by a HR monitor using a chest strap.

2.5.3 Cardiac autonomic function

HR and HRV, were measured using a HR monitor and chest strap (Polar RS800 CX®, Polar Electro OY, Kempele, Finland). The RR intervals were recorded at a sampling rate of 1,000 Hz (25). Participants were instructed to breathe normally and refrain from speaking during the measurement. Raw data were processed using the Elite HRV app (Elite HRV Inc., Asheville, United States), which has been validated for its validity and reliability (26). The analysis of HRV included the root mean square of successive differences between normal heartbeats (RMSSD), the standard deviation of all normal-to-normal intervals (SDNN), and HR.

2.5.4 Hemodynamics

Peripheral systolic (pSBP) and diastolic blood pressure (pDBP), as well as central systolic (cSBP) and diastolic blood pressure (cDBP) measurements, along with pulse wave velocity (PWV), were obtained using the Mobil-O-Graph (24 PWA monitor, IEM, Stolberg, Germany). This device is clinically validated for hemodynamic measurements (27). Custom-fit arm cuffs were placed on the participants' left arm, and at least two readings were obtained for each measurement time point, which were then averaged for analysis.

2.5.5 Ventilation

Ventilation was recorded continuously (breath-by-breath) during the incremental exercise test, the supine rest, the seated rest, and the gaming session using a breath-by-breath gas collection system (Metalyzer 3B, Cortex, Leipzig, Germany). A two-point calibration procedure was conducted according to the manufacturer's guidelines prior to each testing session. The calibration of the oxygen and carbon dioxide sensors was performed with gases of known concentrations. The flow rate was calibrated with a 2-L syringe. In addition, ambient air measurements were conducted before each test.

For the resting EE, participants were instructed to rest in a supine position in a quiet, darkened room, ensuring emotional tranquility. In this position, participants lay flat on their backs with their legs extended and arms resting by their sides, ensuring minimized muscular engagement and facilitating a state of relaxation. The supine rest position was maintained throughout the designated resting period. After a 10-min resting period, values were recorded. EE was then measured for approximately 15 min while participants remained calm and awake. Resting EE was obtained when the participants attained a steady state. Steady states were defined as time intervals of at least 5 min, in which every average minute oxygen consumption and carbon dioxide production changed by less than 10%, and the average respiratory quotient changed by less than 5%.

For the seated and gaming condition, ventilation was assessed throughout the whole condition. The EE for all conditions was calculated from the VO_2 and VCO_2 using the Weir equation (28).

2.6 Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics v. 27.0 (SPSS, Chicago, IL, USA). The results are presented as means ± standard deviation. Student's *t*-tests were performed to determine the possible differences between FIFA and LoL e-athletes at the baseline. A series of group (LoL vs. FIFA) × condition (seated rest vs. gaming) repeated-measures analysis of variance (ANCOVA) were calculated to compare differences between groups. VO_2peak and match result (winning or losing) were included as covariates. Significant interactions or main effects were analyzed using a Bonferroni *post hoc* test. Partial eta-squared (η_p^2) values were calculated to estimate the effect sizes (small effect: $\eta_p^2 = 0.014$, medium effect: $\eta_p^2 = 0.06$, large effect: $\eta_p^2 = 0.14$) for the interactions. Statistical significance was set at $p < 0.05$.

3 Results

No adverse events occurred during the examination sessions in any of the participants. The characteristics of the participants are presented in Table 1. Only one of the LoL e'athlete reported being a semi-professional player earning a share of his main income from esports. All other e-athletes reported being amateur competitive e-athletes, not earning any substantial income from competing. Only male e-athletes participated in this study. There were no significant differences in age, BMI, WHtR, body fat, sitting hours, and gaming hours between the groups (Table 2). According to BMI, 10 e-athletes were classified as being overweight (5 FIFA, 5 LoL) and one (LoL) as being obese. Regarding WHtR only 4 e-athletes (1 FIFA, 3 LoL) were above the established 0.5 health risk threshold for WHtR (29). Similarly, 4 e-athletes (1 FIFA, 3 LoL) had values above the obesity thresholds with respect to body fat (30). FIFA e-athletes reported significantly higher engagement in sports compared to LoL e-athletes and reached a significantly higher VO_2peak. According to VO_2max cutoff values (31) 8 e-athletes (6 FIFA, 2 LoL) were classified as superior to excellent, 16 e-athletes (8 FIFA, 8 LoL) were classified as good to fair, and 3 e-athletes (3 LoL) were classified as very poor to poor. The gaming sessions were higher in the LoL compared to the FIFA group (1217 ± 180 s vs. 864 ± 55 s).

TABLE 1 Participants' outcomes at supine rest.

Outcome	Total (*n* = 27)	FIFA (*n* = 14)	LoL (*n* = 13)	*p*-values	Cohens *d*
HRmean (min^{-1})	67 ± 14	67 ± 15	67 ± 13	.913	.043
RMSSD (ms)	63 ± 39	54 ± 30	73 ± 46	.202	.505
SDNN (ms)	85 ± 32	81 ± 29	88 ± 37	.621	.193
pSBP (mmHg)	122 ± 8	119 ± 5	124 ± 10	.082	.697
pDBP (mmHg)	72 ± 8	71 ± 9	72 ± 7	.655	.174
cSBP (mmHg)	125 ± 12	123 ± 10	127 ± 14	.439	.386
cDBP (mmHg)	75 ± 6	73 ± 5	76 ± 6.7	.406	.416
PWV (m/s)	5.2 ± 0.3	5.1 ± 0.3	5.2 ± 0.3	.326	.386
EE (kcal/day)	2,051 ± 218	2,008 ± 191	2,098 ± 243	.293	.414

Data expressed as the mean ± standard deviations. *p*-values indicate the differences between FIFA and LoL players. HRmean, mean heart rate; RMSSD, root mean square of successive differences between normal heartbeats; SDNN, standard deviation of all normal-to-normal intervals; pSBP, peripheral systolic blood pressure; pDBP, peripheral diastolic blood pressure; cSBP, central systolic blood pressure; cDBP, central diastolic blood pressure; PWV, pulse wave velocity; EE, energy expenditure.

TABLE 2 Participants' characteristics.

Outcome	Total (*n* = 27)	FIFA (*n* = 14)	LoL (*n* = 13)	*p*-values	Cohens *d*
Age (years)	23 ± 3	24 ± 3	23 ± 3	.348	.368
Height (m)	1.79 ± 0.05	1.79 ± 0.05	1.79 ± 0.05	.858	.070
Weight (kg)	76.4 ± 10.0	76.8 ± 8.1	76.0 ± 12.1	.842	.078
BMI (kg/m^2)	24 ± 3	24 ± 2	24 ± 3	.861	0.68
WHtR	0.45 ± 0.04	0.45 ± 0.03	0.45 ± 0.04	.983	.008
Body fat (%)	18.2 ± 5.7	17.0 ± 4.7	19.6 ± 6.5	.240	.464
Sitting hours (h/day)	6.8 ± 2.5	7.4 ± 2.4	5.6 ± 2.4	.130	.215
Sports engagement (h/week)	6.0 ± 3.5	7.7 ± 3.3	4.1 ± 2.7	.008	1.163
Gaming hours (h/week)	9.7 ± 5.9	8.4 ± 4.9	12.3 ± 7.6	.168	.664
VO_2mpeak (ml/min/kg)	47.4 ± 9.1	50.8 ± 9.1	43.7 ± 8.0	.044	.818

Data expressed as the mean ± standard deviations. *p*-values indicate the differences between FIFA and LoL players. BMI, body mass index; WHtR, waist-to-height ratio; VO_2peak, peak oxygen consumption.

Regarding the outcomes at baseline, no significant differences could be detected between the groups (Table 1). According to reference values (32), one LoL e'athlete had high normal blood pressure, and one was classified as hypertensive.

No significant condition × group interactions could be detected for any of the outcomes (Table 3). However, significant main effects for time could be detected for mean HR [F(1,23) = 14.254, $p < 0.001$, $\eta_p^2 = 0.383$]; RMSSD [F(1,22) = 6.428, $p = 0.019$; $\eta_p^2 = 0.226$], pSBP [F(1,25) = 35.620, $p < 0.001$, $\eta_p^2 = 0.588$], pDBP [F(1,25) = 9.356, $p = 0.005$, $\eta_p^2 = 0.272$], cSBP [F(1,25) = 10.471, $p = 0.005$, $\eta_p^2 = 0.369$], cDBP [F(1,25) = 7.288, $p = 0.005$, $\eta_p^2 = 0.313$], PWV [F(1,21) = 0.520, $p = 0.004$, $\eta_p^2 = 0.333$], and EE [F(1,25) = 64.659., $p < 0.001$, $\eta_p^2 = 0.721$]. No significant main effect for group could be detected in any of the outcomes. VO_2peak and match result had no effect on the group × condition interactions or the main effect for time or group (all $p_s > 0.05$).

4 Discussion

The present study aimed to investigate the physiological stress responses of e-athletes during competitive gaming sessions and explore the potential influence of physical fitness. The results of this study show that gaming results in significant physiological reactions, which are likely due to psychophysical stress during gaming and may have implications for the overall health and well-being of e-athletes.

Regarding the outcomes at baseline, no significant differences were detected between the FIFA and LoL group. Interestingly, FIFA e-athletes reported significantly higher engagement in sports compared to LoL e-athletes and achieved a significantly higher VO_2peak, indicating better aerobic fitness. It is possible that e-athletes who compete in sports genre video games may exhibit a greater inclination toward physical sports (9). This assumption is supported by a study on virtual football players revealing high levels of physical activity, with 87% meeting the World Health Organization recommendations for physical activity (33). These levels of physical activity are much higher than those reported in other studies of e-athletes from different game genres (7).

wAnalyzing the group × condition interactions, no significant differences were found for any of the outcomes, indicating that the physiological stress responses during gaming sessions did not differ significantly between the FIFA and LoL group. However, significant main effects for time were observed for HR, RMSSD, pSBP, pDBP, cSBP, cDBP, PWV, and EE suggesting that the gaming sessions elicit physiological responses.

4.1 Cardiac autonomic function

During the gaming sessions, the mean HR showed a significant increase, reaching 40 ± 11% of the HRpeak. The highest HR recorded during the gaming session corresponds to 53 ± 0.1% of HRpeak. These results are consistent with previous research conducted by Yeo et al. (34), which reported a similar increase in HR during a game of LoL. However, conflicting results have been reported for other game titles (35, 36). Regarding the game of FIFA, studies conducted by Siervo et al. (20) and Zimmer et al. (37) reported no significant increase in HR during the game. Interestingly, Siervo et al. (38) even reported a decrease in heart rate while playing FIFA.

The differences in HR responses among studies might be attributed to the competitive or casual nature of the gaming environment. This is support by a study from Chaput et al. (39), who intentionally stimulated a competitive environment in their study and found a significant increase in HR during video gaming compared to a seated control condition. Adachi & Willoughby (40), assessed HR during different game titles and found that only highly competitive games resulted in an increase in HR, further corroborating the influence of competitiveness on HR response during gaming. Our results and these previous findings suggest that differences in HR response are more related to the competitive character of the game than the specific game title.

Regarding HRV, significant main effects for time were observed for RMSSD, reflecting a reduced vagal activity of the heart. However, no effects on SDNN were evident. In a study assessing a game of LoL, Yeo et al. (34), reported a significant increase in low-frequency power, a significant decrease in high-frequency power, and an increase in the ratio between low- and high-frequency components of HRV, indicating a shift towards sympathetic dominance and reduced parasympathetic activity during gameplay. These results align with Chaput et al. (39), who also observed an increase in the

TABLE 3 Changes in outcomes between seated rest and gaming conditions for FIFA and LoL players.

Outcome	FIFA (n = 14)		LOL (n = 13)		p-values		
	Seated rest	Gaming	Seated rest	Gaming	Time × group	Time	Group
HRmean (min^{-1})	69 ± 15	77 ± 18	74 ± 11	81 ± 17	.590	<.001	.443
RMSSD (ms)	69 ± 41	51 ± 29	51 ± 24	48 ± 21	.120	.019	.367
SDNN (ms)	102 ± 44	84 ± 34	83 ± 36	81 ± 33	.231	.131	.432
pSBP (mmHg)	126 ± 14	141 ± 14	125 ± 12	141 ± 12	.827	<.001	.884
pDBP (mmHg)	80 ± 11	86 ± 10	81 ± 8	88 ± 14	.799	.005	.736
cSBP (mmHg)	137 ± 14	138 ± 16	122 ± 13	138 ± 11	.100	.005	.337
cDBP (mmHg)	87 ± 8	93 ± 8	85 ± 7	92 ± 11	.772	.016	.675
PWV (m/s)	5.2 ± 0.4	5.5 ± 0.6	5.1 ± 0.4	5.6 ± 0.4	.479	.004	.792
EE (kcal/min)	1.63 ± 0.19	2.06 ± 0.31	1.51 ± 0.19	1.86 ± 0.20	.404	<.001	.149

Data expressed as the mean ± standard deviations. HRmean, mean heart rate; RMSSD, root mean square of successive differences between normal heartbeats; SDNN, standard deviation of all normal-to-normal intervals; pSBP, peripheral systolic blood pressure; pDBP, peripheral diastolic blood pressure; cSBP, central systolic blood pressure; cDBP, central diastolic blood pressure; PWV, pulse wave velocity; EE, energy expenditure.

low- to high-frequency components ratio of HRV during gaming compared to resting conditions. Due to the limited physical demand of the video games assessed (FIFA and LoL), the results suggest that esports induces mental stress, which has been reported to trigger sympathetic activation and parasympathetic withdrawal (41, 42). Interestingly, no effect of the match result on HRV parameters was detected. This contrasts with a recent study by Machado et al. (43), which indicated that the outcome of the game affected perceived stress and HRV parameters after gaming. However, it is worth noting that in this study, these parameters were assessed after the game rather than throughout.

4.2 Hemodynamics

Playing video games resulted in a significant increase in peripheral and central blood pressure, as well as PWV. Again, no differences could be detected between the two game genres. The results are in line with Chaput et al. (39), who reported a significant increase in systolic as well as diastolic blood pressure during a competitive video game play compared to resting values. Siervo et al. (20) found a significant increase only in pDBP during 1 h of playing violent video games. In a more recent study the same author (38) reported significant higher pSBP during video gaming compared to watching TV. However, the significant differences resulted from a reduction while TV viewing and no changes while video gaming. Similar to our study, the authors found no difference between game genres. Conversely, two studies found differences between game genres, showing that violent video games resulted in more pronounced increases in blood pressure (44, 45). Previous studies suggest that the violent content within video games may create an internal aggressive state that increases arousal and triggers cardiovascular stress responses (45, 46). However, this is not directly supported by the results of our study, as LoL and FIFA are not considered violent video games.

Regrettably, prior investigations have not examined central blood pressure or PWV. PWV, which characterizes the velocity of the central pulse wave and indicates arterial stiffness, serves as an early indicator for existing structural vascular changes and subsequent cardiovascular risks (47). Evidence suggests that PWV is more strongly associated with preclinical organ damage and is a better predictor of future cardiovascular events than peripheral blood pressure (48). The central blood pressure reflects the afterload of the heart and correlates with the myocardial oxygen consumption. Accordingly, the prognostic significance of central blood pressure is evaluated higher than that of peripheral blood pressure (49).

The increase in hemodynamic parameters during gaming could possibly be explained by an sympathetic α-adrenergic stimulation that induces an activation of endothelial cells and smooth muscle cells resulting in systemic vasoconstriction, and increased total peripheral resistance (50, 51).

4.3 Energy expenditure

The EE significantly increased duringesports. During the gaming session the e-athletes reached metabolic equivalent of task (MET) values of 1.6 ± 0.3, which is equivalent to low intensity exercise (52). However, when considering the MET values based on the individual resting EE rather than the standard 3.5 references from the literature, the mean MET values were found to be 1.4 ± 0.2, falling within the definition of sedentary behavior. The highest VO_2 values reached by the e-athletes were 9.64 ± 2.56 ml/min/kg corresponding to $21 \pm 0.1\%$ of their individual VO_2peak.

In a recent study by Kocak (53), MET values during gaming were reported to reach 1.9 MET, indicating light physical activity. On the other hand, Mansoubi et al. (54) found that playing video games resulted in 1.4 METs. While Chaput et al. (39), reported a significant increase in EE during video gaming compared to resting condition, Zimmer et al. (37), did not observe significant changes in EE and VO_2 in participants playing FIFA or the first-person multiplayer shooter Counter-Strike: Global Offensive. Similarly, Haupt et al. (55) did not detect an increase in EE, though it's worth noting that both studies did not employ a competitive setting.

While video gaming does involve repetitive hand and finger movements to control the gamepad, mouse, and keyboard, the impact on EE from these actions may be relatively minor. Instead, the mental stress induced by cognitive engagement and emotional responses seems to trigger sympathetic activation, leading to an increase in EE through beta-adrenergic mechanisms (56). Once again, the competitive setting may provide an explanation for the conflicting results.

4.4 Practical implications

The study provides valuable insights into the physiological stress responses during esports. The findings reveal that gaming sessions, characterized by prolonged sitting and intense mental demands, elicit physiological changes, including increased HR, blood pressure, and EE and decreases in HRV. Considering these responses is crucial when addressing the health risks associated with esports, as gamers may be at risk of experiencing chronic stress outcomes. While short episodes of stress may not pose a significant health risk, repeated and prolonged cardiovascular activation can lead to vascular hypertrophy, progressively increasing peripheral resistance and contributing to the development of established hypertension (57, 58).

This becomes particularly relevant as prolonged gaming sessions become more common (59). Notably, the average online video gamer in America plays for 6.44 h per week (60), and pro-gamers, in particular, spend approximately 9.4 h per day playing video games (61). While casual gaming may not induce strong physiological reactions, competitive gaming settings seem to pose a potential problem. As esports tournaments often span several hours, and online leagues continue to expand, gamers may find themselves increasingly exposed to extended competitive gaming sessions.

Thus, coaches and e-athletes should carefully consider how to optimize training regimens and implement appropriate recovery strategies to reduce stress and promote overall well-being (62). Apart from recovery and stress management strategies, physical exercise may represent a potential countermeasure. Although the present results show that physical fitness had no effect on the stress response experienced during gaming, it is possible that acute exercise may attenuate the stress response. Studies have shown that acute exercise can not only reduce the response to physical stress (22, 63) but also mitigate the response to mental stress (64). Consequently, incorporating physical exercise into the training regimen and conducting short exercise sessions before esports sessions could present a promising approach to decrease acute stress response and mitigate the long-term effects of prolonged and repeated periods of high stress, thus helping to prevent negative health outcomes.

4.5 Limitations

While this study offers valuable insights into the physiological stress responses of e-athletes, some limitations should be considered. One limitation is that the study employed a cross-sectional design, which only provides a snapshot of the participants' physiological stress responses during gaming sessions. Longitudinal studies would be beneficial to investigate the long-term effects of gaming on the health and well-being of e-athletes. Second, we only took blood pressure measurements at the end of the gaming session. Continuous monitoring would have provided a more comprehensive view of the stress response over time. However, as participants' need for full control over their arms and hands continuous monitoring was not feasible during gaming. Third, the study did not account for potential variations in performance levels within and between the two groups, which may have influenced the observed stress responses. A study by Poulus et al. (16) suggests an association between esports performance level and levels of mental toughness, indicating that individuals who are more successful have higher levels of mental toughness. Fourth, the total duration of the gaming sessions differed between the groups, potentially influencing the results. Fifth, the study assessed physiological reactions during competitive online environments but did not examine the stress response in official tournament settings. Physiological reactions in official tournaments might differ due to increased pressure. Nevertheless, the competitive online environment could provide a more accurate representation of the situations e-athletes encounter in their daily gaming experiences. Lastly, only male participants took part in this study, despite gender not being a criterion for inclusion or exclusion. This gender bias is common in esports research (65).

5 Conclusion

This study sheds light on the physiological stress responses of e-athletes during gaming sessions and their potential impact on overall health. Gaming sessions, characterized by prolonged sitting and intense mental demands, lead to significant physiological changes, including increased HR, blood pressure, EE and reduced HRV. Game genre, match results, and physical fitness level had no effect on the stress response. These findings highlight the importance of addressing the health risks associated with esports, as prolonged cardiovascular activation may have adverse effects. Coaches and e-athletes should optimize training regimens to reduce stress responses and ensure a healthy gaming environment without compromising game specific performance. Future research should continue to investigate various game titles and discern the mechanisms (mental, cognitive) behind the psychological responses.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethical Commission of the Faculty of Human Sciences at the University of Bern (Nr. 2021-02-00005). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SK: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Visualization, Writing – original draft, Writing – review & editing. CRN: Conceptualization, Project administration, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Conceptualization and validation of the TILT questionnaire: relationship with IGD and life satisfaction

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Currently, the study of esports is growing within the field of psychology. Among the different variables attracting interest — including stress or psychological factors associated with performance — an emerging concept known as *tilt* is gaining prominence in the literature. However, this construct has yet to be operationalized or defined. Thus, the present study aims to address this gap by defining and conceptualizing TILT while devising and validating a questionnaire to measure the construct in esports players. The initial phase of the study comprised 27 interviews conducted with professional players ($n = 6$), semi-professionals ($n = 8$), amateurs ($n = 8$), and coaches ($n = 5$) to characterize the concept of tilt. Following these interviews, a definition of tilt was formulated, and a panel of five experts in sports psychology and esports proposed a comprehensive set of 53 items. A total of 488 participants (278 males, 210 females), aged 18–50 (mean age = 26.9 years, SD = 7.57), completed the survey, including the 53 tilt items, a questionnaire measuring toxic behavior, and the Internet Gaming Disorder Scale-Short Form (IGDS9-SF). The tilt construct is primarily characterized as a state of frustration escalating into anger, resulting in diminished performance, attention, and recurring negative thoughts about errors. Its onset typically coincides with stressful situations, persisting for approximately 30 min. Through an Exploratory Factor Analysis (EFA), 18 items were retained and categorized into two factors: Causes (7 Items) and Consequences (11 Items) of tilt. The entire questionnaire yielded a Cronbach's α of 0.922, with the first and second factors showing values of 0.854 and 0.890, respectively. Confirmatory factor analysis (CFA) revealed an acceptable fit for the 2-factor solution. Correlations with related constructs, such as Toxic Behavior and IGD, provided preliminary evidence of external validity. Empirical evidence for the validity and internal consistency of the Tilt Scale is robust, indicating its potential utility in future research on the psychological experiences of esports players.

KEYWORDS

eSports, psychometrics, emotion, performance, health, internet gaming disorder

Introduction

The realm of esports is experiencing rapid expansion, as projected figures for 2025 anticipate a significant upswing in both regular subscribers (318 million) and casual viewers (322.7 million). This reflects a notable 19.12% increase from the preceding year (Global eSports market size 2023 and Gough, 2024). Concurrently, research in this domain has witnessed consistent growth over the past decade (Reitman et al., 2020), with scholarly investigations spanning diverse areas such as economics (e.g., Cranmer et al., 2021) and sports science (e.g., Sharpe et al., 2022, 2024a,b). This burgeoning body of research has engendered discussions regarding the multifaceted fields of expertise implicated in esports, marking the initial strides toward formalizing its ontology within the realm of scientific inquiry (Brock, 2023).

In the domain of psychology, particularly within the field of sports psychology, esports and its psychological components have garnered significant attention within the scientific community. Numerous investigations have delved into various facets, encompassing the identification of noteworthy stressors (Smith et al., 2019; Leis and Lautenbach, 2020; Poulus et al., 2022a) and their correlation with mental toughness (Poulus et al., 2020). Additionally, research has explored coping strategies (Leis et al., 2022; Poulus et al., 2022b), sleep quality and habits (Klier et al., 2022), the repercussions of winning or losing streaks in competitive scenarios (Machado et al., 2022), as well as their impact on psychophysiological responses (Mendoza et al., 2021) and self-regulation (Trotter et al., 2023). Furthermore, investigations have delved into the psychological factors underpinning sporting performance (Parshakov and Zavertiaeva, 2018; Nagorsky and Wiemeyer, 2020; Sharpe et al., 2022). This includes examining the influence of emotions (Behnke et al., 2022), the requisite psychological skills (Trotter et al., 2021; Bonilla et al., 2022), positive mental health (Griffith and Sharpe, 2024), the role of personality traits (Birch et al., 2023), the impact of high-pressure situations (Sharpe et al., 2024a), and the effects of streaming while gaming on players' efficiency and in-game behavior over time (Matsui et al., 2020).

The themes currently under investigation in esports exhibit a parallel with subjects extensively studied in sports psychology. Noteworthy examples include the correlation between mental health and performance (Gorczynski et al., 2021), the perspectives of health (Monteiro Pereira et al., 2023), the delineation of crucial psychological skills and their training (Stamatis et al., 2020), skill transfer between esports and traditional sports (Murphy et al., 2020), the use of heart rate variability to index self-regulation (Welsh et al., 2023), and the examination of factors like fundamental needs, attentional control, group cohesion, and decision-making within conventional sporting contexts (Coimbra et al., 2022). However, as the exploration of esports deepens, there is potential for a burgeoning interest in psychological dimensions that either remain understudied or are exclusive to the realm of esports. One such concept, particularly prominent at the professional level, is the phenomenon known as "tilt." This term is familiar to gamers and esports professionals alike, encapsulating moments of anger and frustration experienced during gameplay and competition. This unique psychological aspect adds a distinctive layer to the understanding of performance dynamics in esports.

The concept of *tilt* is not entirely novel, with its origins tracing back to the era of pinball machines, which featured *tilting* mechanisms designed to detect player movements or attempts to manipulate the game. When such actions were detected, the system would either block the movement of the flippers or penalize the player by reducing scores and bonuses. Additionally, a sign with the word "tilt" is illuminated, signaling to the player to cease such behavior to avoid further consequences (Castle, 2020). While tilt found its initial roots in pinball, it gained widespread usage in poker, particularly with the rise of online poker and its expanding player base and audience. Browne (1989) characterized tilt as a mental state marked by a loss of control, directly influencing a player's gameplay style, including strategic decisions, gambling, risk-taking, and endurance through prolonged losing streaks. This "tilted" state was associated with significant monetary losses and correlated with various psychological disorders such as depression, anxiety, and sleep disturbances (Palomäki et al., 2013), even potentially exacerbating gambling disorders (Moreau et al., 2020). Moreover, the duration of this mental state could range from minutes to days and, in exceptional cases, persist for months (Browne, 1989). Tilt in poker often elicits negative emotions such as anger or frustration, which are typically inadequately managed, underscoring the pivotal role of emotional regulation in mitigating tilt (Palomäki et al., 2012). This behavior is often associated with other factors such as substance abuse (e.g., alcohol), extended gambling sessions in attempts to recoup losses, or experiencing prolonged losing streaks (Browne, 1989; Palomäki et al., 2013). Certain individual characteristics, such as high emotional sensitivity or diminished perception of defeat, may exacerbate or reduce the intensity of tilt (Palomäki et al., 2013). To further understand and assess the extent of tilt experienced by poker players, Moreau et al. (2017) devised a questionnaire with 21 items, designed to measure the degree of tilt experienced during poker gameplay, dividing the experience of tilt in two main factors: (a) emotional and behavioral tilt, focusing on irritability, anger and sadness and (b) cognitive tilt, focusing on self-control and bet risk-taking.

Despite the notable impact of "tilt" on the performance and psychological well-being of esports players, its exploration from a psychological perspective has been relatively limited. Emerging evidence suggests that esports athletes perceive the avoidance of negative emotions as crucial to their successful performance, a sentiment that aligns with the characteristics of the tilt phenomenon (Poulus et al., 2022b). In a systematic review centered on emotions and emotional regulation within esports, Beres et al. (2023) underscore the significance of acquiring skills to regulate frustration, anger, and tilt. Similarly, Bonilla et al. (2022) emphasize the imperative nature of learning to manage tilt by cultivating emotional control, given its substantial impact on both performance and psychological well-being. The primary triggers for tilt in esports appear to revolve around consecutive losses or errors made by teammates, inducing emotional states characterized by anger, anxiety, and stress. These emotional responses may escalate to a point where players contemplate abandoning the game (Wu et al., 2021; Sharma et al., 2022) or engage in toxic behaviors such as trash-talking, intentional abandonment, or cheating (Türkay et al., 2020). As we have seen, tilt is a construct that generates a great impact on the performance and well-being of players, its central axis being emotions related to anger and frustration. In any case, the behaviors are not clear, giving rise to other behaviors such as toxicity, decision making or stress, as possible related behaviors.

Study aims

The study aims to establish a comprehensive definition of tilt, elucidating its key characteristics and underlying structure to provide a unified framework guiding future research. Secondly, the study endeavors to develop a psychometric instrument capable of effectively measuring tilt. Lastly, the investigation seeks to explore the relationship between tilt and other pertinent constructs, as illustrated in Figure 1, including internet gaming disorder (IGD; Pontes and Griffiths, 2014) and satisfaction with life (SWLS; Diener et al., 1985). Previous research has shown that Internet Gaming Disorder is linked to a heightened prevalence of psychopathology and impulsivity, alongside diminished levels of life satisfaction and self-esteem (Bargeron and Hormes, 2017). Moreover, these impacts are particularly pronounced in the life satisfaction of teenagers and young adults (Phan et al., 2019; Teng et al., 2020). Nevertheless, the exact nature of the relationships between these variables remains unclear, thereby presenting an opportunity to identify behaviors closely associated with gaming that may serve as early indicators of problematic gaming habits. Consequently, the current study not only establishes a connection between Tilt and IGD or life satisfaction for validation purposes, but also considers Tilt as a potential precursor variable to IGD, offering valuable insights for the development of future prevention and intervention strategies.

The study posits several hypotheses. Firstly, it hypothesizes a positive relationship between TILT and IGD (H_1). Additionally, the study suggests a negative relationship between Life Satisfaction and IGD (H_2), and finally, it posits a negative relationship between TILT and Life Satisfaction (H_3).

Materials and methods

Participants

All participants in the study were individuals proficient in the Spanish language, encompassing both video game enthusiasts and esports players, as well as coaches within the esports domain. In the first phase, 32 semi-structured interviews were conducted. The participants were selected through convenience sampling from international professional and amateur clubs. The inclusion participants were (a) to have participated in a national or international competition in the last split or 3 months, (b) to be part of a club or esports organization and (c) to be training the last month at least 5 days per week or played a minimum of 15 h of ranked matches (Mendoza et al., 2023). The data collection process stopped when information saturation was detected, because enough data was collected for the conclusions and interviews does not give us new information. Five of the initial interviews were excluded after transcription because they did not provide sufficient information when analyzing the preliminary results, leaving 27 participants (Men = 18, Women = 9) with a mean age of 21.7 years (SD =7.91) and 3.2 years (SD = 1,64) of experience. The sample consisted of professional (N = 6), semi-professional (N = 8), amateur (N = 8), and coach (N = 5) players. All data were collected in the third trimester of 2022. In the second phase, a sample calculation using G*Power (version 3.1) software was done, and the minimum needed to make the psychometric analysis and equation model was 223 (Faul et al., 2007; Anthoine et al., 2014). Snowball sampling was employed on discord official clubs and videogames servers, twitter, reedit and mediavida forums, also direct contact with professional and amateur clubs, associations and leagues was made yielding 528 responses, if participants had less than 5 h of playing every week, they were excluded from the study (Mendoza et al., 2023). After debugging the data (i.e., anomalous responses, extreme cases, blank responses, and repeated responses), 488 participants were included in the psychometric study (56.97% men and 43.03% women) with a mean age of 26.9 years (SD = 7.57), dedicating a mean of 3.91 h (SD = 6.82) per day to playing videogames. Participants disclosed their primary gaming preferences, with 62% engaging in esports and 38% playing video games, having a mean of 4.54 years of experience (SD = 2.37) with videogames or esports. Data was collected during the second trimester of 2023. In both phases, inclusion and exclusion criteria for participant selection and classification into esports or videogames were based on guidelines proposed by Mendoza et al. (2023). These criteria were utilized to ascertain participants' status as gamers or esports players and determine their proficiency levels (i.e., professional, semi-professional, or amateur).

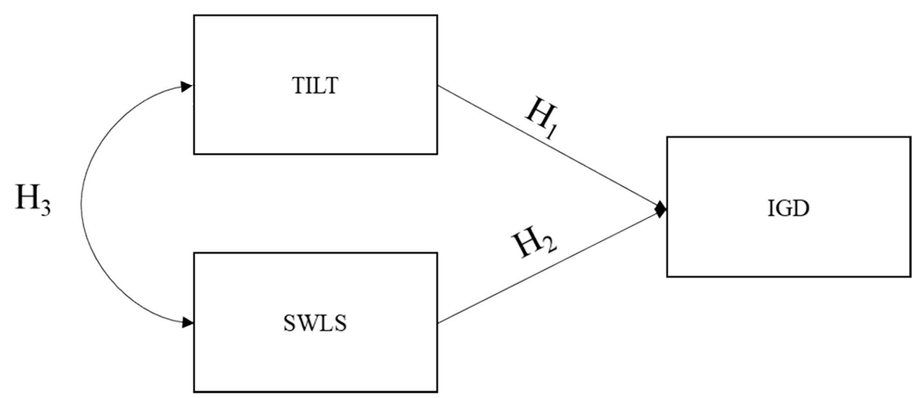

FIGURE 1
Model proposed for this study. SWLS, life satisfaction; IGD, internet gaming disorder.

Instrument

A semi-structured interview was conducted in the first phase, lasting approximately 45 min. The interview covered the following topics: (a) participants' experiences in esports, (b) common experiences related to tilt, (c) key characteristics of tilt, (d) defining the tilt construct, (e) identifying facilitating and protective factors, and (f) exploring the consequences of episodes characterized by high levels of tilt.

In the second phase, participants completed a questionnaire comprising sociodemographic indicators (e.g., gender, age, experience, hours of play per day) along with the following scales.

Tilt questionnaire (TILTQ)

As can be seen in Figure 2, different versions of the questionnaire were constructed during the process of creating the measurement scale. The final version utilized in the study consisted of 18 items (see Table 1), categorized into two dimensions: causes of tilt (comprising 7 items) and consequences of tilt (comprising 11 items; see Table 1 for items), and asked to indicate the extent to which you have experienced the following situations during a game in the last 15 days. Respondents rated each item on a five-point Likert-type scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Total scores ranged from 18 to 90 points, with higher scores indicating greater tilt. In the current investigation, Cronbach's Alpha coefficients were 0.89 for the causes dimension, 0.89 for the consequences dimension, and 0.92 for the overall tilt scale.

Internet gaming disorder (IGD)

IGD was evaluated using the Spanish version of the Internet Gaming Disorder Scale-Short Form (IGDS9-SF; Beranuy et al., 2020). This scale comprises nine items designed to assess the severity of IGD

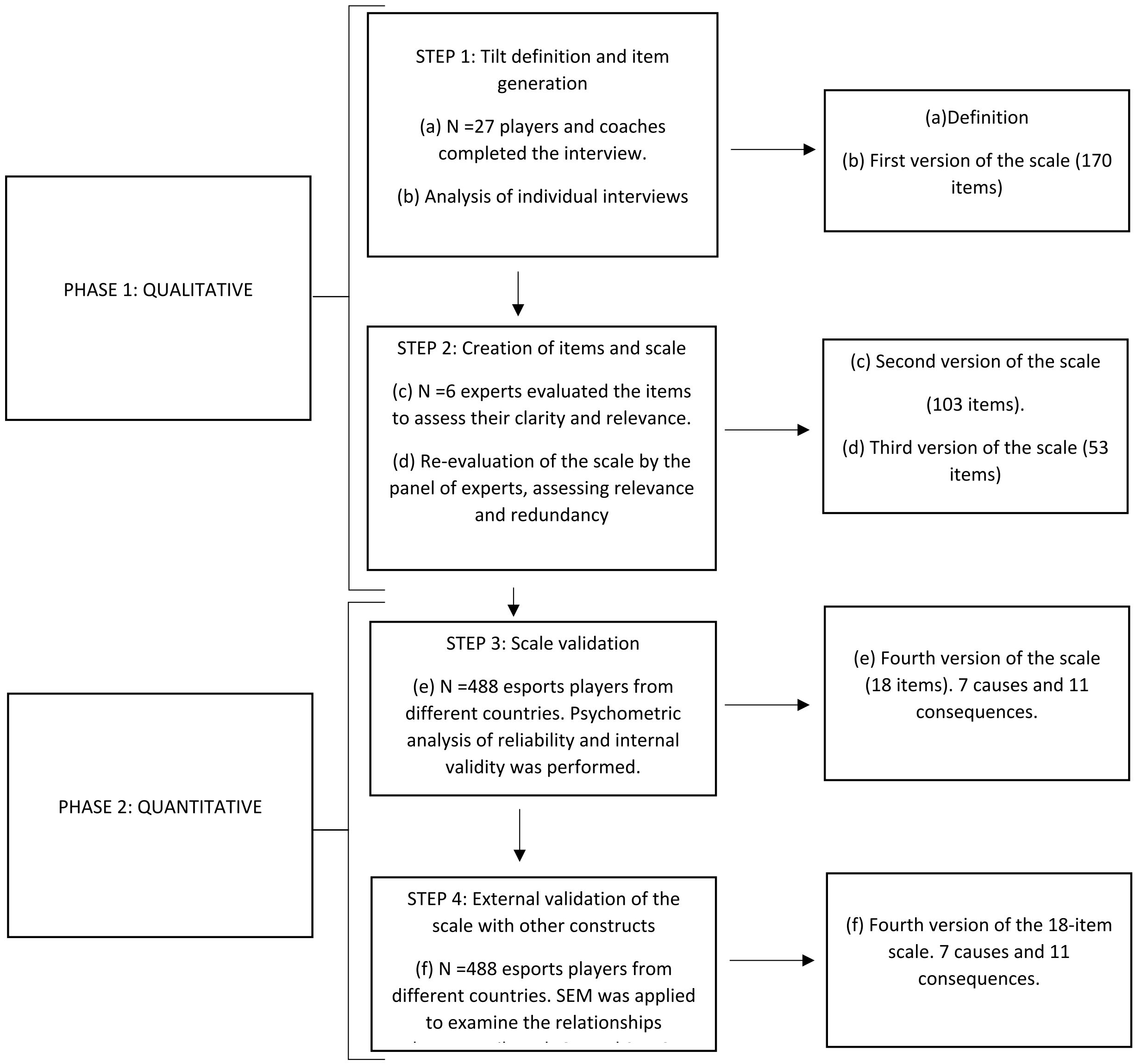

FIGURE 2
Process of creating the definition of tilt and the measurement scale.

TABLE 1 Items and structure of the TILTQ.

Structure	Factor loadings
TILTQ Please indicate the extent to which you have experienced the following situations during a game in the last 15 days.	
Causes	
1. I have lost because of things in the game I could not control.	0.667
2. I have failed to make important moves.	0.671
3. I have made mistakes in things I know I can do well.	0.695
4. I have made wrong decisions.	0.793
5. I failed even though I knew what I had to do.	0.713
6. I have felt that I have more ability than I have been able to demonstrate.	0.799
7. I have played frustrating games.	0.728
Consequences	
1. I have felt that the game was not fair.	0.585
2. I have exploded with rage.	0.620
3. I have felt irritated.	0.758
4. I have made decisions without thinking.	0.785
5. I have found it hard to concentrate.	0.714
6. I have had mood swings due to the outcome of my games.	0.764
7. I have felt that I have no energy.	0.567
8. I have felt that I have been on a losing streak that I could not get out of.	0.751
9. I have played hastily.	0.731
10. I have continued to play even though I did not feel like it.	0.618
11. I have written off games as lost.	0.668

and its impact on online and offline gaming activities over a 12-month period. Each item is rated on a 5-point Likert scale, ranging from 1 (Never) to 5 (Very often). Total scores on the scale can range from 9 to 45, with higher scores indicating a greater risk of IGD. In the present study, the Cronbach's Alpha coefficient for the IGDS9-SF was 0.83.

Satisfaction with Life Scale (SWLS). This self-report questionnaire (Diener et al., 1985) is used to measure overall life satisfaction. Each item is scored on a five-point Likert scale, ranging from 1 (Strongly disagree) to 7 (Strongly agree). Total scores can range from 5 to 35, with higher scores indicating greater life satisfaction. The Cronbach's Alpha obtained in the present study was 0.81.

Study design and procedure

A two-phase study was conducted using a mixed-methods design, since, as mentioned above, the variables and factors underpinning tilt have not yet been adequately defined and studied within the field of esports. A qualitative methodology was used (Phase 1), conducting individual interviews with players and coaches — professional, semi-professional, and amateur — in order to establish a definition of the construct and develop a scale to measure tilt. A quantitative methodology was adopted (Phase 2) to carry out the relevant psychometric analysis, providing external validation of the scale with IGD and SWLS to test the various hypotheses (see Figure 2).

The study employed a mixed-methods research design comprising two distinct phases, as delineated in Figure 2. During the first phase, interviews were conducted in the third trimester of 2022. Participants were selected through convenience sampling and were provided with a comprehensive briefing on the study's aims and procedures, subsequently giving informed consent by signing a consent form. Interviews were administered through both face-to-face interactions and online sessions utilizing platforms such as Discord or Teams. All interview sessions were recorded and subsequently transcribed for the purpose of thematic analysis. Following the interview phase, a precise definition of "Tilt" was formulated, and items for the initial questionnaire were generated. This questionnaire, along with the definition, underwent rigorous evaluation by a panel consisting of six experts (Mage = 42.1; SD = 12.5) in sports psychology, sports science, or esports, with more than 5 years of experience in the field as researchers and practitioners. From an initial pool of 170 items, the expert panel selected 53 items for further consideration.

Moving on to the second phase, an online survey was disseminated via Kobotoolbox during the second trimester of 2023, reaching participants through various channels and social media platforms such as Twitter and Reddit. The survey encompassed gamers of diverse proficiency levels and nationalities, all of whom were Spanish-speaking and capable of responding through mobile devices, tablets, or computers. Prior to initiating the questionnaire, participants were required to review and confirm their agreement with the informed consent statement. In cases of non-consent, participants were courteously directed to the survey closure page and thanked for their time. All data collected were securely stored in an anonymous and encrypted format within the university database of the principal investigator (PI). Access to any identifying information was strictly restricted to the PI alone, ensuring confidentiality and data security in strict adherence to the guidelines set forth by the American Psychological Association (2020). Moreover, ethical approval for the study was obtained from the Research Ethics Committee and awarded by the lead institution (CEEAH 5525).

Data analysis

In the first phase, a thematic analysis was conducted to categorize the various responses obtained, utilizing the ATLAS.ti software. Following the classification of themes, a series of definitions and key concepts were formulated, serving as the basis for creating the questionnaire items. Subsequently, the same panel of experts described before individually assessed the definitions and items pertaining to the tilt concept. During the item selection process following the guidelines proposed by Lynn (1986), items receiving unanimous agreement from all six experts proceeded directly to the next phase. In contrast, those with between 3 and 5 agreements underwent further review, incorporating suggestions provided by the experts, and making a second round where if 5 experts agreed the item has been included. Finally, items receiving fewer than three affirmative responses were eliminated. Additionally, suggestions for new items were allowed to enhance the item pool. This iterative procedure continued until the

TABLE 2 Main tilt-related themes.

Concept/theme	When it occurs	Quotations
Frustration	When failing, feeling defeated, or when goals are not achieved	"When you are tilted, you feel like nothing is worthwhile, and no matter how much you do, you are not going to achieve your goals."
Anger	When making mistakes, when teammates do not respond well, and when losing regardless of the amount of time spent playing.	"It is like a snowball that keeps getting bigger and bigger until you finally explode."
Loss of control	When it is not known why a player wins or loses; it feels like the game is rigged; or experiencing the feeling of playing well but losing anyway.	"The game is often unfair, there are champions who are overpowered, or it is simply impossible to win."
Decision-making	Situations with multiple failures, tunnel vision, high pressure, and intense competition.	"I have been "tilted" many times when competing, and all of a sudden, I make a move or play in a way that does not make sense."
Mood swings	In prolonged situations of frustration, anger, and defeats.	"When I start to play, I always feel motivated, but as you tilt, you gradually lose that motivation and end up losing the enthusiasm you had when you began."
In-game behavior	When faced with repeated failures, the bad behavior of other colleagues or toxic situations.	"When you get tilted, you start doing things you should not, even to the point of being toxic, changing your strategies, or playing just for the sake of it" or "If you are tilted, often you do not stop playing matches because you know that if you win one, the tilt will disappear, but of course when you play tilted you play worse, and you have more chances to keep losing and losing."

final version comprising 53 items was obtained and subjected to psychometric analysis.

In the second phase, the psychometric properties of the TILTQ instrument were assessed. Item-total analysis was carried out, while skewness and kurtosis were calculated to check the normality of the data. Subsequently, an exploratory factor analysis (EFA) with Oblimin rotation was conducted, as suggested by Lloret-Segura et al. (2014), to determine the factor structure. Items with factor loadings below 0.4 or loading on another dimension were eliminated. Additionally, a scree plot was utilized to determine the number of dimensions.

Once the factors and their component items had been selected, confirmatory factor analysis (CFA) was conducted using conventional fit indices, including Comparative Fit Index (CFI) > 0.9, Tucker-Lewis Index (TLI) > 0.9, Root mean square error of approximation (RMESEA) < 0.08, and Goodness of Fit Index (GFI) > 0.9 (Browne and Cudeck, 1993; Marsh et al., 2005). A correlation matrix between IGD, tilt, and SWLS was generated to assess external validity. Finally, structural equation modeling was employed to test the proposed hypotheses, adhering to the same fit criteria as those adopted for the CFA.

All analyses were conducted using JASP 0.18.1.0 statistical software (JASP Team, 2023).

Results

The results of the exploratory thematic analysis, summarizing the concepts and themes associated with tilt, are presented in Table 2. Two primary dimensions emerged: the causes that trigger tilt and the subsequent consequences experienced once in a tilted state. Participants highlighted that these dimensions fed into each other during the different level states of tilt.

Based on these themes and their components, a definition was formulated and approved by the expert judges. This definition offers a conceptualization of tilt as follows: "Behavior that increases gradually with repeated errors, by oneself or others in a context where performance is required, which generates frustration. This causes anger, emotional lability, decreased performance, attention, and recurrent negative thoughts about the error or defeat. Tilt is closely related to stressful situations, varying from seconds to hours, with an average duration of 30 min."

An item analysis was conducted before carrying out the exploratory factor analysis of the tilt scale. All items followed a normal distribution, with no outlier responses and no floor or ceiling effects detected. Consequently, all 53 items were retained for further analysis. A comparison of item scores between the upper and lower 25% of the sample revealed significant differences for all items, indicating that the items effectively discriminated between individuals with varying levels of tilt. Before conducting the exploratory factor analysis, the Kaiser-Meyer-Olkin (KMO) index was calculated, yielding a value exceeding 0.9 according to Hutcheson and Sofroniou (1999), this value can be classified as superb. Additionally, Bartlett's test of sphericity was significant ($X^2 = 3706.65$; df = 118; $p < 0.001$), confirming the suitability of the data and items for factor analysis.

An Oblimin rotation was employed for the exploratory factor analysis, anticipating relationships between the potential factors. The scree plot suggested the presence of three factors (see Figure 3).

Upon observing that 10 items had factor loadings below 0.4, they were excluded from the analysis. When evaluating the nine items grouped in the third factor, it was noted that they represented an amalgamation of poorly related concepts and were eliminated. Following these modifications, 34 items were retained for a two-factor solution (eigenvalue >1). However, this solution revealed that 2 items loaded inversely, 8 items loaded on both factors and 6 items loaded below 0.4, resulting in their elimination. Consequently, 18 items remained, with 7 items in the causes factor and 11 in the consequences factor, explaining 51.2% of the variance.

Once the factor structure was determined, reliability was assessed using Cronbach's Alpha (α) and McDonald's Omega (ω) coefficients. For the total tilt scale, McDonald's Omega was calculated as $\omega = 0.922$ (0.912–0.932), while Cronbach's Alpha was $\alpha = 0.921$ (0.910–0.931). Similarly, for the subscale measuring causes, McDonald's Omega was $\omega = 0.855$ (0.836–0.875), and Cronbach's Alpha was $\alpha = 0.854$ (0.834–0.873). For the subscale measuring consequences, McDonald's Omega was $\omega = 0.891$ (0.877–0.906), and Cronbach's Alpha was $\alpha = 0.890$ (0.875–0.904). Based on these results, we can conclude that the total scale and its subscales show adequate reliability indices with scores above 0.70 and less than 0.95, with both subscales scoring less than 0.90 showing not redundancy with a good consistence (Tavakol and Dennick, 2011; Viladrich et al., 2017). The correlation matrix between the total scale and its subscales (see Table 3) shows a high positive correlation.

To assess construct validity, a confirmatory factor analysis (CFA) was conducted using both factors (see Table 1) covariance between factor was 0.81, showing the existence of a general factor called tilt. The model demonstrated acceptable fit indices ($X^2 = 484.794$; $p < 0.001$), as shown in Table 4, and all factor loadings exceed 0.55 which can be considered good or above (Comrey and Lee, 1992). Given that Byrne (2010) states that the use of both fit indices and factor loadings should be used when assessing factorial validity our results suggest that the proposed model adequately explains the underlying structure of the tilt construct.

To evaluate convergent validity (see Table 5), it can be observed that the correlations between the tilt scale and its subscales are considerably higher than those observed with other constructs. This indicates that the tilt scale effectively discriminates from related constructs, particularly Internet Gaming Disorder, which could be a regarded as a similar construct since it addresses negative states and consequences related to video gaming. Second, all correlations are statistically significant. Specifically, there is a positive correlation between tilt and IGD and a negative correlation between tilt and life satisfaction. These findings are consistent with theoretical predictions, indicating that the tilt construct behaves as expected in relation to previously established constructs.

Finally, we tested the hypothesized structural equation model for the relationships between tilt, Internet Gaming Disorder, and life satisfaction (see Figure 1). The results indicate an acceptable fit for the model ($X^2 = 39.456$; $p < 0.001$), providing further evidence of external validity.

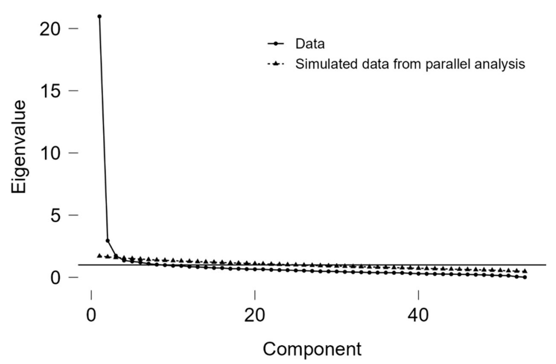

FIGURE 3
Scree plot showing the initial solution.

The model reveals a positive relationship between tilt and IGD, as well as a negative relationship between life satisfaction and IGD. Additionally, a negative covariance between tilt and life satisfaction is evident. The model explains 21% of the variance in IGD (see Figure 4).

Discussion

The primary aim of this study was to elucidate the concept of tilt, introduce a measurement instrument for the construct, and investigate its association with Internet Gaming Disorder and Life Satisfaction. The initial findings of this research pertain to the proposed definition and components of tilt, as detailed in Table 2. These results suggest that tilt is not an impulsive behavior with an undetermined origin; rather, it exhibits identifiable causes intricately connected to the act of playing video games or participating in esports, particularly within performance-driven scenarios that necessitate the execution of skills to surmount challenges presented by the game. The study revealed that individuals, when faced with the inability to achieve performance goals, undergo a growing sense of frustration that intensifies with prolonged play and repeated attempts to meet their objectives, ultimately triggering the onset of tilt. It is crucial to recognize that the phenomenon of tilt unfolds gradually, "snowballing" over time, often culminating in either explosive manifestations, such as outbursts of anger, or passive expressions, such as a loss of energy and motivation. Adding to the intricacy of tilt is the inclination for individuals experiencing it to persist in gameplay, driven by the hope that achieving victory may alleviate their tilt. Conversely, there is a proclivity for tilted individuals to resort to toxic behaviors, such as quitting the game or engaging in verbal abuse, thereby posing risks to both themselves and others. This complexity in the progression of tilt aligns with prior research in domains like poker (Browne, 1989; Moreau et al., 2017), which shares certain similarities with tilt observed in video games and esports due to the shared underlying logic of gameplay. The study's findings also resonate with existing research in esports; for instance, Sharma et al. (2022) and Wu et al. (2021) have previously reported tilt-related consequences similar to those identified in the present study, including the inclination to quit games prompted by anger and frustration. Moreover, the research by

TABLE 3 Correlation between factors and scale.

Variable	1		2		3
1. TILT causes	–				
2. TILT consequences	0.688	***	–		
3. Total TILT	0.884	***	0.948	***	–

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE 4 Fit indices of the confirmatory factor analysis.

Index	Value
Comparative Fit Index (CFI)	0.952
Tucker-Lewis Index (TLI)	0.945
Root mean square error of approximation (RMSEA)	0.073

TABLE 5 Correlation matrix for the scale and related variables.

Variable	1		2		3		4		5
1. Causes	–								
2. Consequences	0.688	***	-						
3. TILT	0.884	***	0.948	***	-				
4. IGD	0.213	***	0.409	***	0.357	***	-		
5. Satisfaction	−0.339	***	−0.261	***	−0.318	***	−0.315	***	-

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

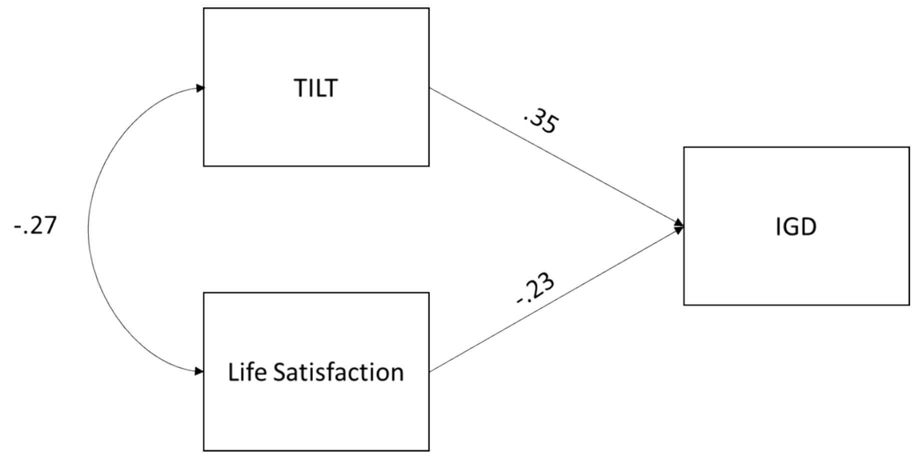

FIGURE 4
Structural equation model of the variables studied.

Türkay et al. (2020) implies that individuals experiencing tilt-like situations are more predisposed to engaging in toxic behaviors or repeated mistakes in performance situations.

Regarding the second aim, the results generated a final 18-item questionnaire, divided into two scales, 7 items for causes and 11 items for consequences (see Table 1 and Suppplementary file).

The questionnaire demonstrates adequate reliability, strong factorial validity with acceptable fit indices, and an explained variance of 51.7%. Additionally, when evaluating external validity, the construct satisfactorily discriminates from other constructs and shows expected relationships IGD and life satisfaction. Consequently, this questionnaire serves as an initially reliable and valid measure for assessing tilt among video game and esports players.

Finally, three hypotheses were formulated to evaluate whether the observed relationships aligned with our expectations, that is, with IGD and life satisfaction to clarify whether tilt and satisfaction are potential predictors of IGD. As depicted in Figure 4, these hypotheses were confirmed, yielding a model that explains 21.7% of the variance. Upon closer examination, it is evident that IGD shows a negative association with life satisfaction, in line with previous research (e.g., Bargeron and Hormes, 2017), and a positive correlation with tilt. Thus, based on the preliminary results, those players prone to high levels of tilt could present a greater risk of developing problematic relationships with video games, which could lead to IGD. Additionally, tilt is found to co-vary with life satisfaction, indicating that esports players experiencing tilt tend to report lower levels of life satisfaction and vice versa. These findings open a new path to understanding the precursor variables involved in Internet gaming disorder, not just the contextual ones or the direct effects on self-esteem, impulsivity or self-esteem (Bargeron and Hormes, 2017), bringing us closer to unraveling the different behaviors that gamers follow to develop a bad relationship with video games or even psychopathology.

These findings pave the way for a new field of study in esports research and opens future lines of research. First, our measurement instrument offers the opportunity to explore the concept of tilt and analyze its relationship with other psychological variables in the context of esports, such as emotional regulation, particularly given that tilt and emotional lability are closely related (Poulus et al., 2022b; Beres et al., 2023), also it allows us to explore its relationship with other cognitive variables like attention or memory (Pedraza-Ramirez et al., 2020). Second, it would be interesting to investigate the relationship between tilt and potentially related variables such as toxicity (Türkay et al., 2020) or the structural characteristics of video games (Wood et al., 2004; Feliu et al., 2023), so we can go further in the understanding of internet gaming disorder specific behaviors. Moreover, it would be useful to develop psychological techniques to mitigate tilt. Such interventions are particularly important to practitioners if we consider the substantial impact of tilt on players and the esports ecosystem; therefore, implementing strategies to reduce individual discomfort, enhance performance, and diminish toxicity could prove highly beneficial to support the overall sustainability of video gaming and esports.

The present study has several limitations that warrant consideration. First, the study sample is limited to a Spanish-speaking culture, which restricts the generalizability of the findings to other cultural contexts. Second, while the tilt instrument effectively measures individual player dimensions, it does not fully capture how teammate behaviors may contribute to tilt. Future versions of the TILTQ could address this limitation by incorporating items specifically designed to assess teammate-induced tilt, thus creating separate versions for individual and team games/esports.

Conclusion

The present study aimed to bridge the existing gap in research by providing a comprehensive definition and conceptual framework for TILT. In doing so, the study developed and validated a questionnaire designed to effectively measure the construct specifically in esports players. The obtained findings facilitated the conceptualization and quantification of the tilt phenomenon, laying the foundation for exploring its intricate relationships with other variables of interest. With the established validity and internal consistency of the Tilt Scale, this study introduces a valuable tool that holds promise for future research endeavors on the psychological experiences of esports players, transcending diverse cultural contexts. Furthermore, the study paves the way for a novel avenue of research, contributing to an enhanced understanding of this specific behavior within the realms of video gaming and esports.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Research Ethics Committee of the Autonomous University of Barcelona with code CEEAH 5525. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

IB: Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing, Data curation, Funding acquisition, Investigation, Project administration, Software, Supervision, Validation. AC: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. PB: Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. BS: Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. AM-C: Formal analysis, Funding acquisition, Supervision, Validation, Writing – original draft, Writing – review & editing. DM: Funding acquisition, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. CV: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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How strenuous is esports? Perceived physical exertion and physical state during competitive video gaming

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Introduction: Esports or competitive video gaming is a rapidly growing sector and an integral part of today's (youth) culture. Esports athletes are exposed to a variety of burdens, that can potentially impact an athlete's health and performance. Therefore, it is important that esports athletes are aware of (physical) burden and exertion associated with esports. For this purpose, a study was conducted to evaluate the influence of competitive video gaming on the perceived physical exertion and the perceived physical state (PEPS).
Methods: Thirty-two healthy male esports athletes participated in two competitive video gaming sessions lasting 90–120 min, interrupted by a 10-minute passive sitting break. Repeated measures of perceived physical exertion (Borg Categorial Ratio-10 scale) and perceived physical state were recorded before, during, and after each video game session. Repeated measures ANOVA and Friedman's test were used for statistical analysis.
Results: The results showed a significant difference in all dimensions of the PEPS ($p < 0.05$) as well as in Borg scale ($p < 0.001$). Post-hoc tests revealed significant increases in Borg scale between baseline measurements (T0: 1.0 ± 1.0) and after the first competitive video gaming session (T1: 2.4 ± 1.3, $p < 0.001$), as well as after the second competitive video gaming session (T3: 3.0 ± 1.7, $p < 0.001$). Furthermore, there was a significant reduction in perceived exertion between the measurement time after the first competitive video gaming session (T1) and the break (T2: 1.3 ± 1.2, $p < 0.001$). The PEPS dimensions activation, trained, and mobility showed similar significant changes in post-hoc analysis.
Discussion: The results indicate that the perceived physical burden significantly increases during esports participation. As the duration of competitive video gaming extends, the perceived physical state decreases and perceived physical exertion increases. A passive break between two video game sessions can at least partially restore physical exertion and physical state. However, this break neither returns the scores to their baseline levels nor prevents a further decline in scores during the second video game session. Over time and with a lack of observation, this could result in health and performance limitations.

KEYWORDS
video games, RPE, sedentary behavior, ANOVA, fatigue, rest

1 Introduction

The video gaming sector has been a rapidly growing area for several years. This has led to a massive increase in video game players, spectators, and the global video game market over the past decade (1). It is estimated that there were 3.4 billion video game players globally in 2023 (1). One part of the video gaming sector is electronic sports (esports), also known as competitive video gaming (2). In esports, athletes compete against each other in different virtual environments. Today, esports athletes compete in tournaments with millions of dollars in prize money, attract millions of viewers and serve as role models, especially for young people (3, 4). Therefore, it is not a short-term trend, but an integral part of today's (youth) culture and competitive sports industry.

With the growing interest in esports, the performance and health of esports athletes has become a focus for organizations and researchers. Esports athletes train between 4 and 10 h/day to develop (game-)specific abilities depending on their skill level and the game genre (5, 6). The requirements range from mechanical skills to control the digital environment, to tactical-cognitive skills to plan moves or cooperate with teammates, to psychological skills such as resilience (7). Currently, there is a lack of evidence in which esports games players spend the most time playing, or which skills require the most training to develop. In addition, esports athletes are exposed to a variety of burdens, that can affect an athlete's health and/or performance (8, 9). Various biopsychosocial stressors such as prolonged sitting (10), high mental stress, or team issues are present in esports (11). A recent systematic review on stress in esports revealed different psychophysiological responses (12). Interestingly, the participation in non-competitive esports games does not seem to be associated with changes. In competitive settings however, mixed results have been found, indicating potential changes in the heart rate, heart rate variability, and blood pressure (12). Research has shown that esports athletes' perceptions of psychological stress can be influenced by winning or losing their games (13).

In addition to these psychophysiological responses, the physical burdens of esports and its potential consequences have previously been discussed (14). Video gaming and esports by their (current) nature are mostly sedentary behaviors combined physical inactivity (15), monotonous and prolonged sitting (8), and repetitive movements of the upper extremities (16). Except for exercise or virtual reality games, which require physical movements to interact with the digital environment and could increase physical activity (17). As a result, excessive video gaming may lead to the occurrence of musculoskeletal disorders (14). Consequently, not only could the health of esports athletes be compromised, but their performance may also be affected due to impairments. Such physical ailments could lead to early retirement (9). Therefore, it is important that esports athletes are aware of physical burden and exertion in order to counteract these consequences. This requires good self- and body perception. However, there is a lack of evidence on body perception during competitive video gaming. As mentioned above, perceived physical exertion is of particular interest in terms of injury prevention and intensity control. The findings could be useful for load management, intensity control and self-perception in esports.

Therefore, the overall aim of this study is to examine the perceived physical burdens of esports athletes during competitive video gaming. We hypothesized that the perceived physical exertion would increase and the perceived physical state would decrease over time.

2 Materials and methods

2.1 Study design

This study used a repeated measures, within-group, non-randomized design. Due to the exploratory approach and the non-standardizable nature of the video game activity the study focused on within-group study design. This allows the participants to act as their own control, reducing individual variability for between-group comparisons. The study took place in the laboratory of the Institute of Movement Therapy and Movement-oriented Prevention and Rehabilitation at the German Sport University Cologne. Between 06/2023 and 12/2023 esports athletes were recruited for a five-to-six-hour investigation. The participants took part in two competitive video gaming sessions of 90–120 min interrupted by a 10-minute passive sitting break (Figure 1). At the measurement points (T0-T3) and during video game play, objective and subjective parameters were examined. The study protocol followed the ethical principles defined in the declaration of Helsinki and were approved by the ethical committee of the German Sport University Cologne (reference: 093/2023).

2.2 Participants

Thirty-two healthy male esports athletes from Germany met the following inclusion criteria: (1) esports athlete defined by being in the top 20% of the in-game ranking system, (2) playing computer-based multiplayer online battle arena (MOBA) or first-person shooter (FPS) games, (3) mouse and keyboard usage, (4) mouse operation with the right hand, (5) using a mouse sensitivity between 400 and 3,000 dots per inch (dpi), (6) aged between 18

FIGURE 1
Study design.

and 35 years. The age range reflects the majority of esports athletes (5, 10, 18). Participants were excluded if they reported (1) acute or chronic upper body musculoskeletal disorders, (2) uncorrected visual impairment, (3) severe migraine or epilepsy, (4) medication-induced vigilance or vision impairment, or (5) severe physical or cognitive stress on the previous day. Participants were recruited via social media (*Discord, Instagram, LinkedIn*), in person at video game venues or at various universities in Cologne Germany, as well as through esports organizations. Participant recruitment was open to all genders.

2.3 Procedure

The study was conducted by trained and experienced instructors and included subjective and objective parameters. This article will focus on the subjective parameters and procedures. The biomechanical analysis is only partially mentioned to understand the structure of the entire study protocol and will be part of another article. Participants were asked to avoid cognitively or physically demanding activities on the day before and on the day of the test. They were also asked to abstain from alcohol for 12 h, from caffeinated beverages for five hours, and not to use any lotions/creams on the day of the test. At the beginning of the examination, participants were informed about the study protocol and signed the informed consent form. Inclusion and exclusion criteria were then checked, and anthropometric data were recorded. In addition to body weight and height, circumferences, and dimensions of the upper body were collected without clothing. Subsequent recoding of electromyographic, electrocardiographic and motion capture data was prepared. After the preparation for the biomechanical analysis, participants were asked to complete a partially standardized online questionnaire at the testing station.

The standardized test station consisted of an adjustable chair with demounted armrest for a better hip motion capture, an adjustable desk, and ten motion capture cameras. While the participants answered the questionnaire, the instructors checked the objective data for plausibility. After completing the questionnaire, participants were allowed to warm up and adjust their settings in the video game for ten minutes. The video game played could be chosen by the participant. The esports title had to be a MOBA (League of Legends, Defense of the Ancients 2) or FPS (Counter-Strike, Valorant, Overwatch, Rainbow Six Siege) video game. Immediately prior to the start of the measurement, participants were asked to do their best to win the games.

After this preparation phase (T0) and at each other measurement point (T1-T3), participants were asked to answer short questionnaires about their current perceived physical state and the current physical exertion. Measurements commenced with the first competitive video gaming session. To ensure typical stress conditions similar to the official competitions, participants had to play ranked games using their main accounts. During the competitive video gaming sessions, participants were asked to rate their perceived physical exertion every 15 min. The sessions ended within 90–120 min, depending on the time each game was finished. Typically, a single game lasted 25–45 min. Therefore, participants had to play multiple games to meet the minimum of 90 min of data collection. If a video game session lasted longer than 120 min, the data recordings for that session were stopped. The competitive video gaming sessions were interrupted by a 10-minute passive sitting break at another chair with armrests. Break duration reflects the average break between tournament games, which may vary between games and tournaments (19–21). Eating and drinking were permitted without restrictions on specific foods or caloric intake. Only caffeinated beverages and smoking were prohibited. Participants were not allowed to be physically active during the break. After the second competitive video game session, a five-minute passive sitting recovery period was part of the study. During this phase, only heart rate monitoring was continued. All other data collection was already completed (Figure 1).

2.4 Measuring instruments & outcomes

The questionnaire was designed to assess socio-demographic data, video gaming behavior, physical activity, sitting time, and prevalence of musculoskeletal disorders of esports athletes. It was administered via the online survey tool Unipark (*Questback GmbH, Cologne, Germany*). The questionnaire contained a total of 38–50 questions, depending on participants' answers to filter questions. First, demographic data such as age, gender, education, and employment status of the participants were collected. The wording and assessment of these questions were designed according to the standards of the German Federal Statistical Office (22). Since an appropriate and validated questionnaire was not available, questions about video game and esports training behaviors were self-designed.

Participants were first asked about their video game genre, their primary video game title and their in-game rank. In order to make the rank distribution of each game comparable, the percentage ranks are given and subdivided: ≤1%, ≤5%, ≤10%, ≤20%. Secondly, the video game experience in years, their mouse dpi and in-game (mouse) sensitivity were queried. Thirdly, they were asked about their video game playing time in hours per week differentiated according by mode:

- "Alone/without human players against human opponents (PvP)"
- "With human players against human opponents (Coop PvP)"
- "Alone/without human players against computer-controlled opponents (PvE)"
- "With human players against computer-controlled opponents (Coop PvE)"

The sum corresponded to the total video game playtime per week. The questionnaire also asked if the participants were a member of an esports club and participated in regular esports training. If they participated in esports training, the follow-up question about the organization of the training contained the following responses:

- "I train in a (regional) club with a coach"

- "I train in a (regional) club without a coach"
- "I train in a team with a coach"
- "I train in a team without a coach"
- "I train with friends"
- "I train alone or with random opponents/teammates"

Multiple answers were possible. In addition, esports training content was asked on a 4-point rating scale ("never", "sometimes", "frequently", "always"):

- Game mechanics
- Tactics
- Game analysis (own games)
- Game analysis (opponents and role models)
- Team building
- Communication with team members
- Reaction speed
- Targeted training of fine motor skills/precision/mechanical skills
- Dealing with stressful situations (in the game)
- Physical fitness
- Relaxation/regeneration
- Other

Participants were additionally queried regarding the proportion of their esports training conducted on PCs and the average weekly training duration in hours. The second part of the questionnaire covered health issues such as overall health, musculoskeletal disorders, physical activity and sitting time. The overall health was observed with a single question and includes the overall health status of the last 4 weeks on a 5-point rating scale: "poor", "fair", "good", "very good", "excellent".

Musculoskeletal disorders were evaluated with the validated German version of the *Nordic Musculoskeletal Questionnaire* (NMQ) (23, 24). Physical activity was assessed with the *European Health Interview Survey—Physical Activity Questionnaire* (EHIS-PAQ) (25). The *Sedentary Behavior Questionnaire* (SBQ) was used to assess weekday and weekend seating times (26). The EHIS-PAQ and SBQ were also available in a validated German version.

In addition to this baseline questionnaire, a modified version of the *Borg Categorial-Ratio-10 scale* (CR10) was used to assess only the physical exertion at the measurement points (T0-T3) and every 15-minutes in the competitive video gaming sessions (27). The scale rated the perceived physical exertion from 0 "No physical exertion" to 10 "Extremely strong physical exertion" (Supplementary Material Figure S1). In addition, a German validated list of adjectives was used to assess participants' current perceived physical state (PEPS) (28). The PEPS is recommended for monitoring changes in perceived physical state during exercise classes to detect short-term changes and was used at measurement points. The assessment is based on a six-point rating scale. Only the endpoints of the scale are verbally anchored (0 = "not at all"; 5 = "completely"). A self-translated English version can be found in the Supplementary Materials.

2.5 Sample size

An *a priori* power analysis was performed using *G*Power* software (version 3.1.9.7) to estimate the sample size required for repeated measures of variance (one-way ANOVA) (29). Due to a lack of scientific evidence, we assumed a mean effect size (f) of 0.25, a significance level (α) of 0.05, and a power (1-β) of 0.8. The analysis included 2 groups (within factors), 4 measurements (T0-T3), a correlation between repeated measures set at 0.5, and a non-sphericity correction (e) of 1. The results indicated a required sample size of $N = 24$.

2.6 Statistical methods

All statistical analysis were performed using *R* software (version 4.3.1) (30). Data was checked for completeness, plausibility and outliers. Participants were contacted if plausibility was questionable (e.g., reported >6 h/day of exercise). Outliers were excluded if they were greater or less than three times the standard deviation (31). Descriptive statistics are presented as the mean ± standard deviation (SD).

After this the prerequisites for a repeated measures ANOVA were examined. Normal distribution was visually analyzed at each measurement point for each variable using quantile-quantile (QQ) plots. Normal distribution was assumed if data appears as roughly a straight line. QQ plots for each variable are included in the supplementary (Supplementary Material Figures S2–S7). Sphericity was tested with *Mauchly's test*. If the assumption was violated ($p \leq 0.5$), the *Greenhouse-Geisser* correction was used. Changes over time were tested by repeated measures ANOVA with *Bonferroni* post-hoc analysis. Effect sizes were calculated by using *Cohen's d* and interpreted as small = 0.2, moderate = 0.5 and large = 0.8 effect (32). The *Friedman* test was used for non-normally distributed data. Multiple pairwise comparisons were estimated using the all-pairs test with exact *p*-values and *Bonferroni* adjustment (33). Effect sizes for Friedmann are calculated only for the overall effect with *Kendall's W*. The coefficient ranges from 0 = indicating no relationship, to 1 = indicating a perfect relationship (34). The significance level for all analyses was set at $p < 0.05$. In line with the open science principle, all data as well as the R-syntax will be available one year after publication and can be found in the supplementary.

3 Results

3.1 Participants

Table 1 displays the sample characteristics. In total, 32 male participants, with an average age of 23.8 years (± 3.4), were included in the study without any dropouts. Sociodemographic data revealed that 85% of participants held at least an A-level degree (higher education entrance qualification) and 69% were currently college students. Average physical activity level was

TABLE 1 Sample characteristics.

Variables	N	Percent	Mean	SD
Anthropometric	32			
Age [years]			23.8	3.4
Height [cm]			180.2	6.7
Weight [kg]			80.8	13.9
Body-mass-index [kg/m^2]			24.8	3.7
Physical behavior	32			
Physical activity [min/week]			307.8	327.9
Sedentary time workdays [h/day]			8.4	3.4
Sedentary time weekends [h/day]			10.1	3.3
Video game behavior	32			
Video game playtime [h/day]			3.6	1.95
Video game experience [years]			12.6	4.26
Video game genre	32			
MOBA	22	69		
FPS	10	31		
In-game rank distribution	32			
1%	9	28		
5%	10	31		
10%	6	19		
20%	7	22		
Highest degree	32			
Secondary school	1	3		
High school	1	3		
Technical college entry	3	9		
A level	22	69		
University degree	5	16		
Occupation	32			
School student	1	3		
College student	22	69		
Full-time employed	2	6		
Part-time employed	4	12		
Marginal employed	1	3		
Vocational training	1	3		
Unemployed	1	3		

307.8 min/week (± 3.4) and mean sedentary time on workdays was 8.4 h/day (± 3.4). On average, participants spent 3.6 h/day (± 2.0) playing video games, with MOBA being the dominant genre among them with 69%. Every participant achieved a ranking within the top 20% of their respective in-game ranking systems. Additionally, 59% achieved rankings in the top 5% or higher.

The musculoskeletal complaints with all temporal prevalences can be found in Table 2. With regard to the one-year prevalence of musculoskeletal complaints, neck discomfort was the most common complaint among the participants (Table 2). Hand and wrist discomfort were the most common complaints for both four-week and seven-day prevalence.

Figure 2 shows the exact training content. Only 15 out of 32 esports athletes participate in regular esports training. They are most likely to train either alone (53.3%), in a team (53.3%), in a team with a coach (40.0%) or with friends (40.0%). There is minimal training with an esports club (26.7%) or with a club and with a coach (6.7%).

3.2 Perceived physical state

Figures 3–6 displays the box plots of the perceived physical condition during the competitive video gaming sessions. The results of the ANOVA with repeated measures show a significant difference in all dimensions of the PEPS: activation ($p < 0.001$, $\eta^2 = 0.26$), trained ($p < 0.001$, $\eta^2 = 0.08$), health ($p = 0.014$, $\eta^2 = 0.08$) and mobility ($p < 0.001$, $\eta^2 = 0.13$). However, the post-hoc tests revealed that only T0 differs from T3 in the health dimension ($p = 0.039$). In the other three dimensions, all measurement times differ significantly from each other with exception of T0 to T2. Overall, there was a decrease over time. The activation dimension went from 4.19 ± 0.62 at T0 to 2.89 ± 1.16 at T3 (−26%). The trained dimension decreased from 3.25 ± 0.85 to 2.59 ± 0.85 (−13.2%) and mobility dimension from 3.43 ± 0.67 to 2.58 ± 0.93 (−17%). In addition, all show a moderate to large effect size. The results of all post-hoc tests are shown in in the supplementary (Supplementary Material Table S1).

3.3 Borg scale

Figure 7 shows the boxplots of the Borg scale at the four measurement points. The Friedmann test indicates significant differences between the measurement times according to the Borg scale ($p < 0.001$, $\omega = 0.66$). The post-hoc tests revealed significant differences between baseline (T0) measurements

TABLE 2 Prevalences of musculoskeletal disorders for different body parts.

Body part	One-year prevalence *n* (%)	Restricted by pain last year *n* (%)	Four-week prevalence *n* (%)	Seven-day prevalence *n* (%)
Neck	16 (50.0)	2 (6.3)	5 (15.6)	2 (6.3)
Shoulders and upper arms	7 (21.9)	3 (9.4)	3 (9.4)	2 (6.3)
Elbows and forearms	4 (12.5)	2 (6.3)	2 (6.3)	0 (0.0)
Hands and wrists	9 (28.1)	3 (9.4)	6 (18.8)	4 (12.5)
Thoracic spine	10 (31.3)	0 (0.0)	3 (9.4)	1 (3.1)
Lumbar spine	10 (31.3)	5 (15.6)	4 (12.5)	1 (3.1)
Hip joints and thighs	3 (9.4)	2 (6.3)	2 (6.3)	1 (3.1)
Knee joints	4 (12.5)	1 (3.1)	3 (9.4)	3 (9.4)
Lower leg	4 (12.5)	2 (6.3)	1 (3.1)	0 (0.0)
Feet and ankles	5 (15.6)	3 (9.4)	4 (12.5)	2 (6.3)

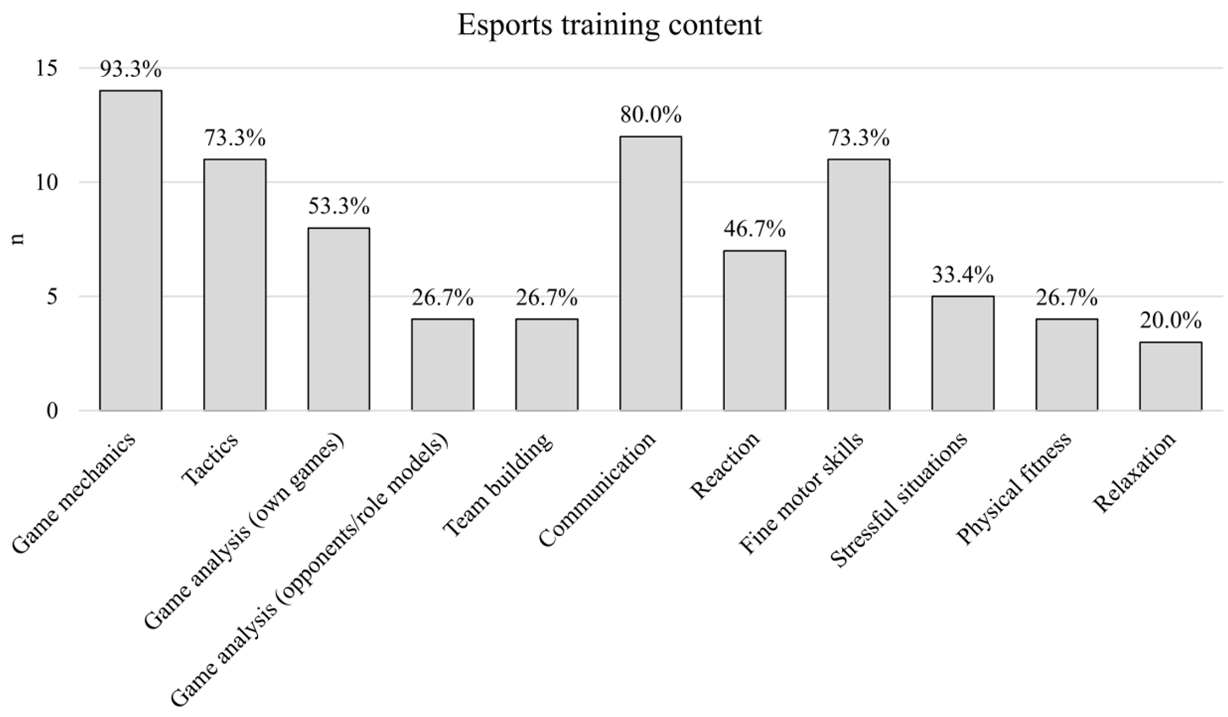

FIGURE 2
Content of esports athletes' structured trainings (*n* = 15). Values represented participants who stated that they frequently or always train for that aspect in their training sessions.

(1.0 ± 1.0) and after the first (T1) competitive video gaming session (2.4 ± 1.3, $p < 0.001$) as well as after the second (T3) competitive video gaming session (3 ± 1.7, $p < 0.001$). Accordingly, Borg scale increased by 2 points over the entire measurement, which corresponds to an increase of 20%. Furthermore, there was a significant difference between the measurement time after the first competitive video gaming session and the break (T2) (1.3 ± 1.2, $p < 0.001$). Lastly, there was also a significant difference between T2 and T3 ($p < 0.001$).

Considering the measurement times of the borg scale every 15 min during the competitive video gaming sessions, the results of the Friedmann test also show significant differences ($p < 0.001$, $\omega = 0.25$). Figure 8 displays the box plots of the borg scale with measurement points every 15 min during the competitive video gaming sessions. For reasons of clarity, only the most important significances are shown in the figure. The results of the post-hoc tests between all time points can be found in the supplementary (Supplementary Material Table S3).

4 Discussion

The purpose of this study was to examine the perceived physical burdens of esports athletes. Thirty-two male esports athletes participated in two 90–120-minute competitive video gaming sessions and reported their perceived physical exertion and perceived physical state. The main finding of this study is that the perceived physical burdens significantly increase during esports. As the duration of competitive video gaming extends, the perceived physical state decreased and the perceived physical exertion increased. Therefore, the hypothesis can be confirmed. However, a 10-minute passive break between competitive video gaming sessions only temporarily reduced perceived physical burdens.

4.1 Perceived physical burdens in esports

Each PEPS dimension was associated with significant decreases over time (see Figures 3–6). The largest decrease was recorded in the activation dimension (−26%) and the lowest in health (−4%). With exception of health, every dimension also indicated significant changes between measurement points. It seems logical that a complex and solid construct like health would not be affected by a temporary mental and sedentary activity like esports. In addition, the control variables "physical pain" and "physical discomfort", which are related to the health dimension (28), did not show a significant change between measurement points (Supplementary Material Table S2). A possible reason could be the short duration of video gaming (3–4 h), which might not be sufficient to develop pain or health issues. Additionally, musculoskeletal disorders are often a result of chronicity, which takes time to develop (35, 36). Therefore, playing video games repeatedly for extended periods could potentially impact physical health and the perceived physical state (14). The other PEPS dimensions exhibited similar changes

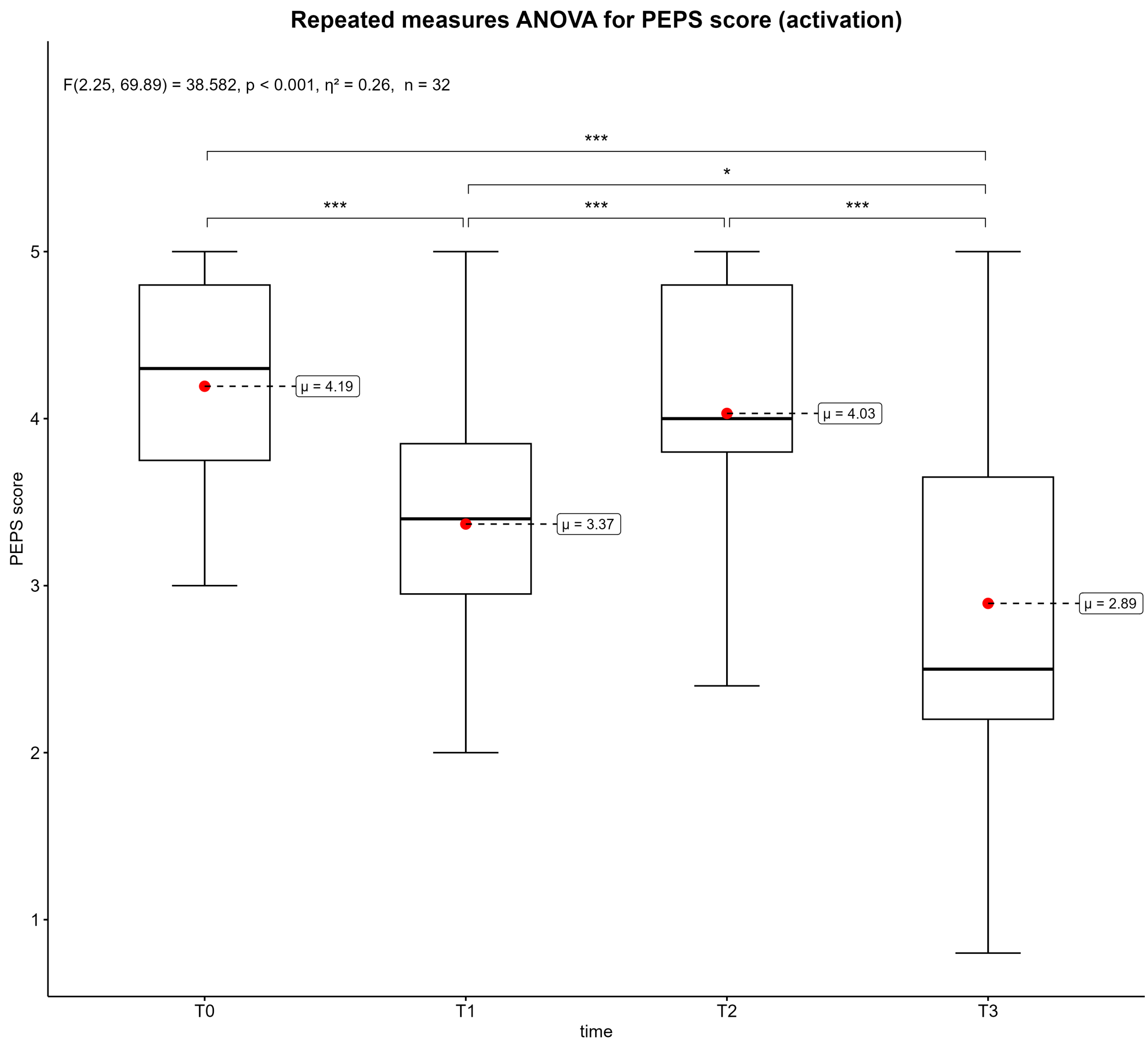

FIGURE 3
Box plots of the PEPS dimension activation across the measurement points. T0 = baseline, T1 = after the first competitive video gaming session, T2 = after the ten-minute break, T3 = after the second competitive video gaming session. *: $p \le 0.05$, **: $p \le 0.01$, ***: $p \le 0.001$ with *Greenhouse-Geisser* correction.

of the PEPS scale. A decrease after both competitive video gaming sessions and a recovery after the break, with the decrease in the second phase being greater than in the first. This could indicate that a 10-minute break between two competitive video gaming sessions could have a positive impact on perceived physical state. However, this break does not restore the PEPS scores to their baseline levels, nor does it prevent a further decline in PEPS scores during the subsequent video game session. In particular, the second session (T2-T3) showed large effect sizes in all PEPS dimensions except the health dimension (Supplementary Material Table S1). Consequently, regular breaks could have a beneficial effect on perceived physical burdens but cannot prevent esports athletes from an increase of these perceived burdens over time. The duration or type of breaks as well as the accumulation of loads could explain this. In relation to different types of breaks, similar results were shown for executive function (37). This study compared walking, sitting, supine rest and no break between 60 and 75 min of FPS gaming. The results suggest that walking and continuous play lead to significantly better executive function scores than supine rest (37). The results of a recently published review, which summarized the positive effects of active breaks in sedentary adults, are partially consistent with these findings (38). According to the authors, metabolic, cardiovascular, and cognitive improvements are associated with light to moderate physical activity or intermittent standing. At the same time, active breaks may mitigate abnormal vascular and hormonal changes which are associated with excessive sitting (38). Consequently, regular breaks could not only improve

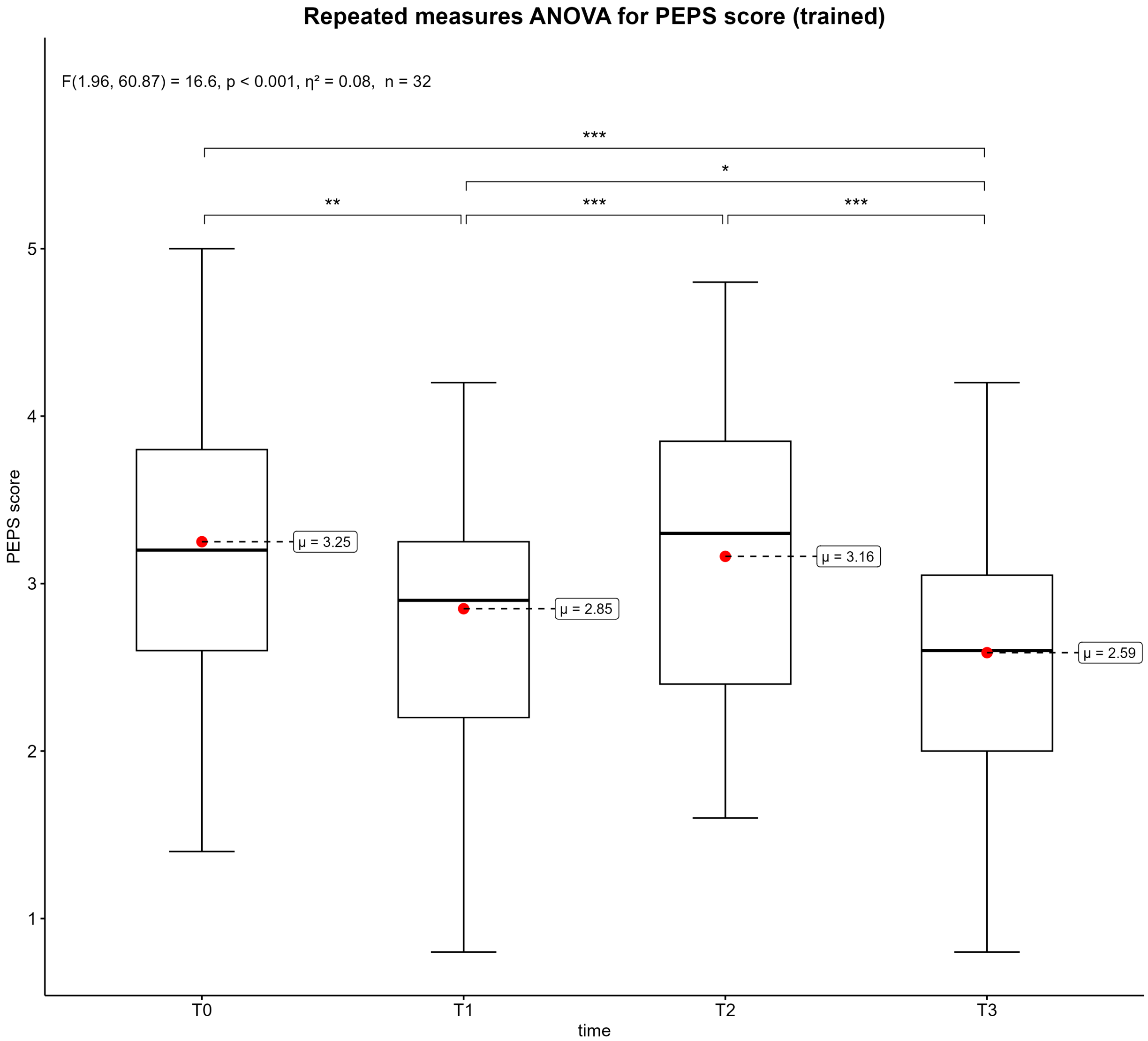

FIGURE 4
Box plots of the PEPS dimension trained across the measurement points. T0 = baseline, T1 = after the first competitive video gaming session, T2 = after the ten-minute break, T3 = after the second competitive video gaming session. *: $p \leq 0.05$, **: $p \leq 0.01$, ***: $p \leq 0.001$, with *Greenhouse-Geisser* correction.

performance of esports athletes, but also benefit their health and body perception. Specifically, the implementation of active break routines should be strongly encouraged.

The distribution pattern of Borg ratings at measurement points is similar to that of the PEPS ratings. The reverse scaling should be taken into account. Therefore, the perceived physical exertion increased significantly during competitive video gaming sessions and decreased after the break (Figure 7). The overall (T0-T3) increase in mean Borg scale was from "very weak" (=1) to "moderate" (=3). More detailed insights were gathered from continuous Borg scores during competitive video gaming (Figure 8). The values fluctuate and do not form a linear increase. Unexpectedly, the highest Borg score of the first session was reached at the penultimate measurement point (T0-75). Similarly, a higher score was achieved in the second phase at T2-60 than at T2-75. The nature of competitive video gaming may be the reason. In order to compete with other esports athletes of the same skill level, competitors must join queues. Depending on their skill level and the availability of other esports athletes, the queue time can vary (39). This can result in higher scattering and different peaks of Borg scale. But even 90-minutes of competitive video gaming significantly increased the Borg scores. Thus, 3–4 h of esports noticeable increase the perceived physical exertion. In addition, a 10-minute break can provide short-term recovery from physical exertion. However, compared to esports training durations of up to 11 h/day (40) or tournament conditions it is concerning that even this shorter duration of competitive video gaming produces such significant changes. As mentioned above, loads could accumulate and lead to higher perceived exertions and burdens over time. Only one

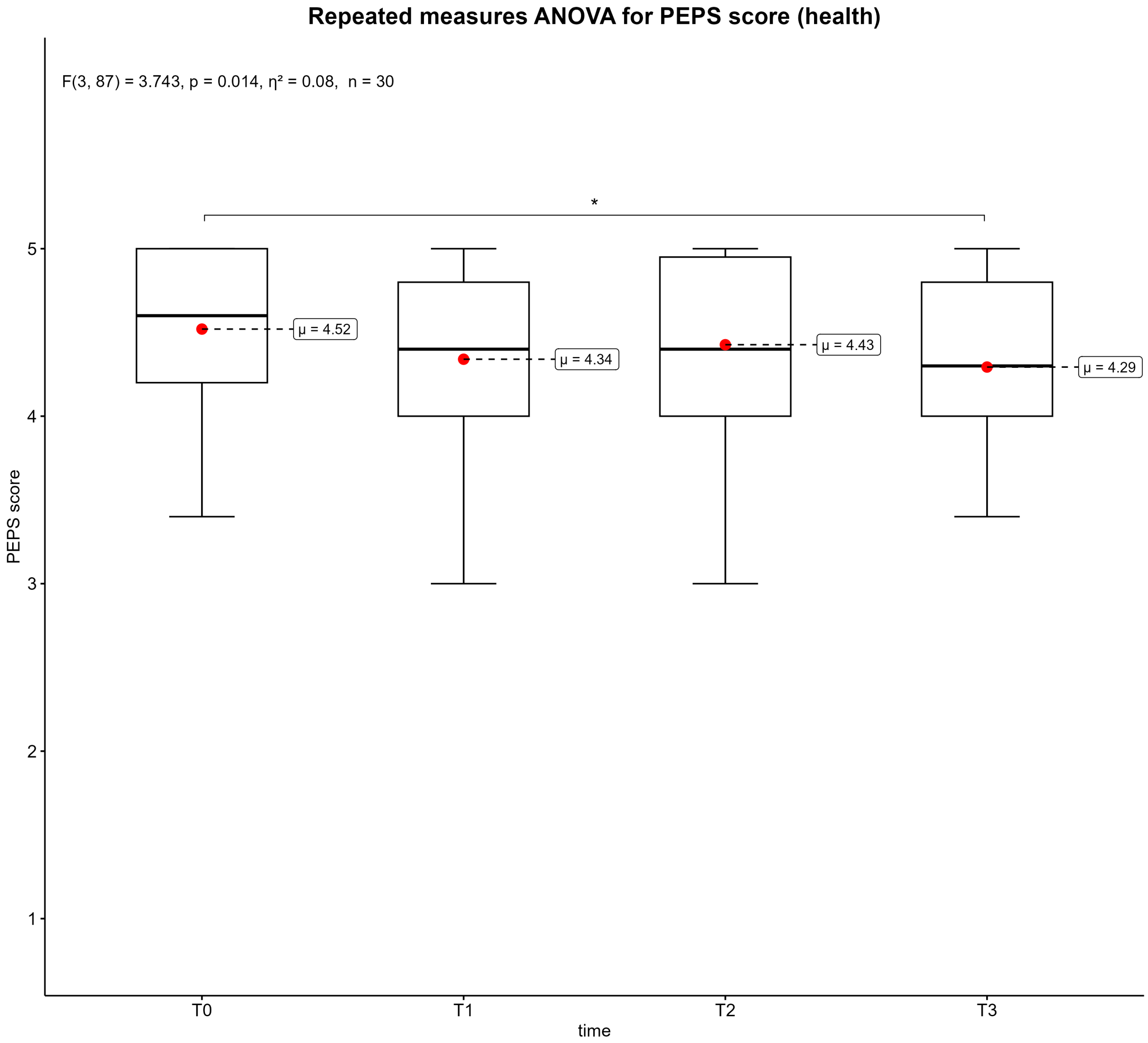

FIGURE 5
Box plots of the PEPS dimension health across the measurement points. T0 = baseline, T1 = after the first competitive video gaming session, T2 = after the ten-minute break, T3 = after the second competitive video gaming session. *: $p \le 0.05$, **: $p \le 0.01$, ***: $p \le 0.001$.

other study used Borg scale with video gamers, but only after playing (37). The study showed Borg scores on the original scale (6–20) with a mean of 11.3–13.4, indicating "fairly light" to "somewhat hard" intensities. In this case, the highest scores were reached after continuous, uninterrupted video game play, but without significant differences from the other groups (37). Thus, the ratings are similar to the Borg scale, but they differ in terms of methodology. What distinguishes the present study is the application of time series analysis to the Borg scale. However, this is an indication of the perceived burdens that playing video games places on esports athletes. Related results were found for prolonged sitting for 4 h and an increase in perceived discomfort in different body parts (41). This could be a possible reason for an increase in the Borg score, but as mentioned above, physical discomfort or pain did not increase significantly in the present study. Therefore, it can be assumed that the Borg score increased independently of discomfort or pain. In conclusion, in the current study esports athletes perceived moderate physical exertion after 3–4 h of competitive video gaming. In addition, this study shows that a passive break between two sessions can at least partially restore physical exertion and physical state. Nevertheless, future research should evaluate various types of breaks and break durations to gain a better understanding of their potential health and performance benefits. This understanding can then be used to implement breaks into esports training in a more meaningful manner.

4.2 Limitations and strengths

The results of this work should be understood in the context of certain limitations. The study was designed without a control group

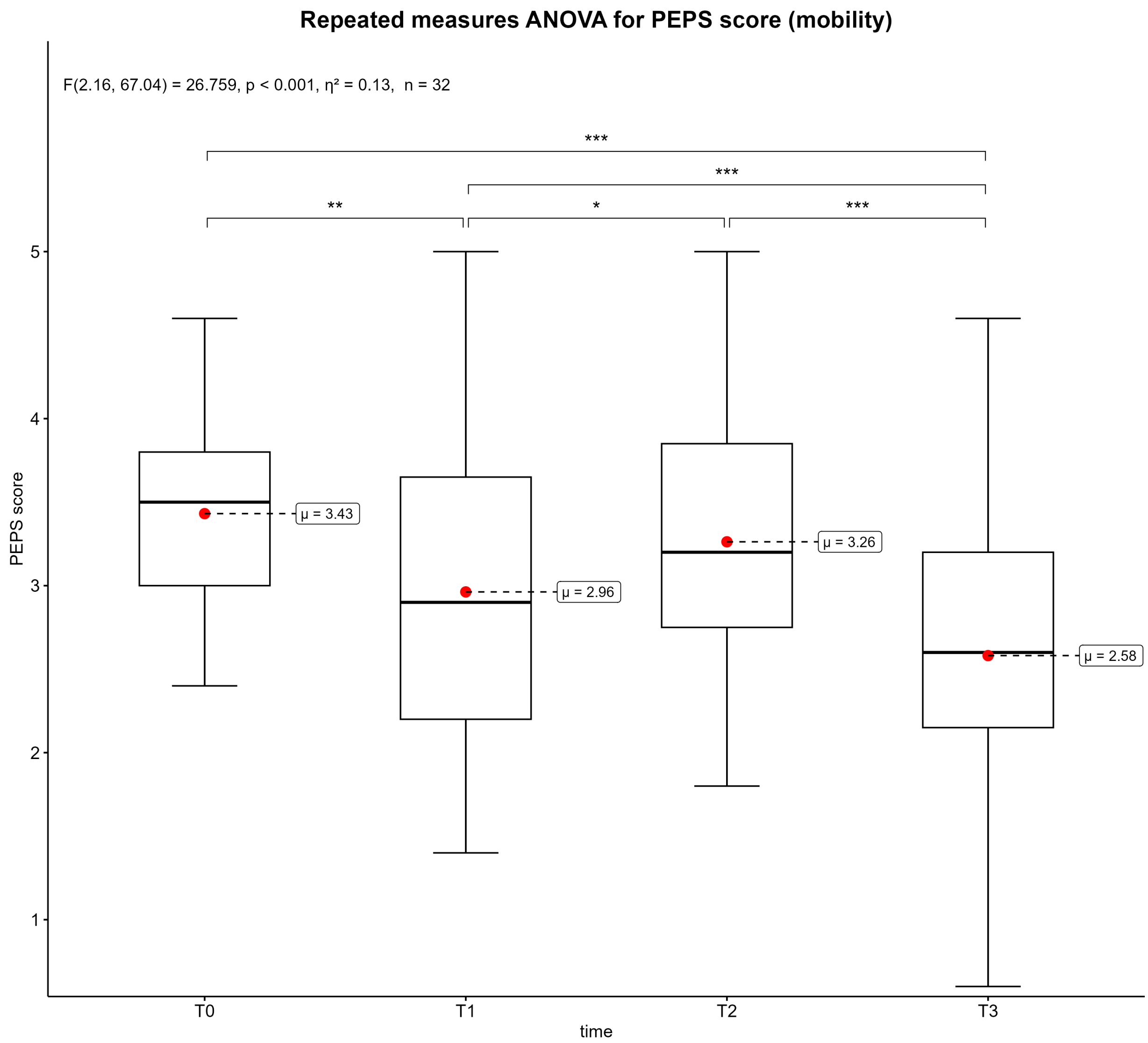

FIGURE 6
Box plots of the PEPS dimension mobility across the measurement points. T0 = baseline, T1 = after the first competitive video gaming session, T2 = after the ten-minute break, T3 = after the second competitive video gaming session. *: $p \leq 0.05$, **: $p \leq 0.01$, ***: $p \leq 0.001$, with *Greenhouse-Geisser* correction.

or comparison, which limits the causality and may lead to biased results. In addition, competitive video game time ranged between 90 and 120 min per session. Therefore, some participants played longer periods of time, which can affect the results. In contrast, during these competitive video game sessions, participants had to wait in queue for their games. This queue time was not recorded but can vary from few seconds up to 10 min. This time often depends on the rank of the esports athletes and increases with rank. As result, some participants had less time to play competitively. Moreover, esports athletes out of different video game genres (MOBA, FPS) were included, due to the suspected similar exposure. Because of the sample size, the groups were not compared and the statistical models were not adjusted for this. Furthermore, no validated measuring instrument for perceived physical burdens in esports exists. Therefore, measuring instrument were used that are validated, but originally designed for physically active behavior. This can result in bias. In addition, the interpretation of the PEPS dimension activation should also be viewed critically. This dimension consists of the adjectives energy less, exhausted, drained, flabby, and limp, and could also be associated with mental processes. Mental capacity could easily be affected by mental workload, such as esports. This could lead to less differentiation between mental and physical activation after competitive video gaming sessions. In contrast, (light) physical activity results in increased scores on the activation dimension (28), which could be due to physical or psychological factors. Additionally, only male esports athletes registered for this study. Therefore, the recruitment strategy should have been modified to attempt to improve the recruitment rate of non-male esports athletes and to avoid gender bias.

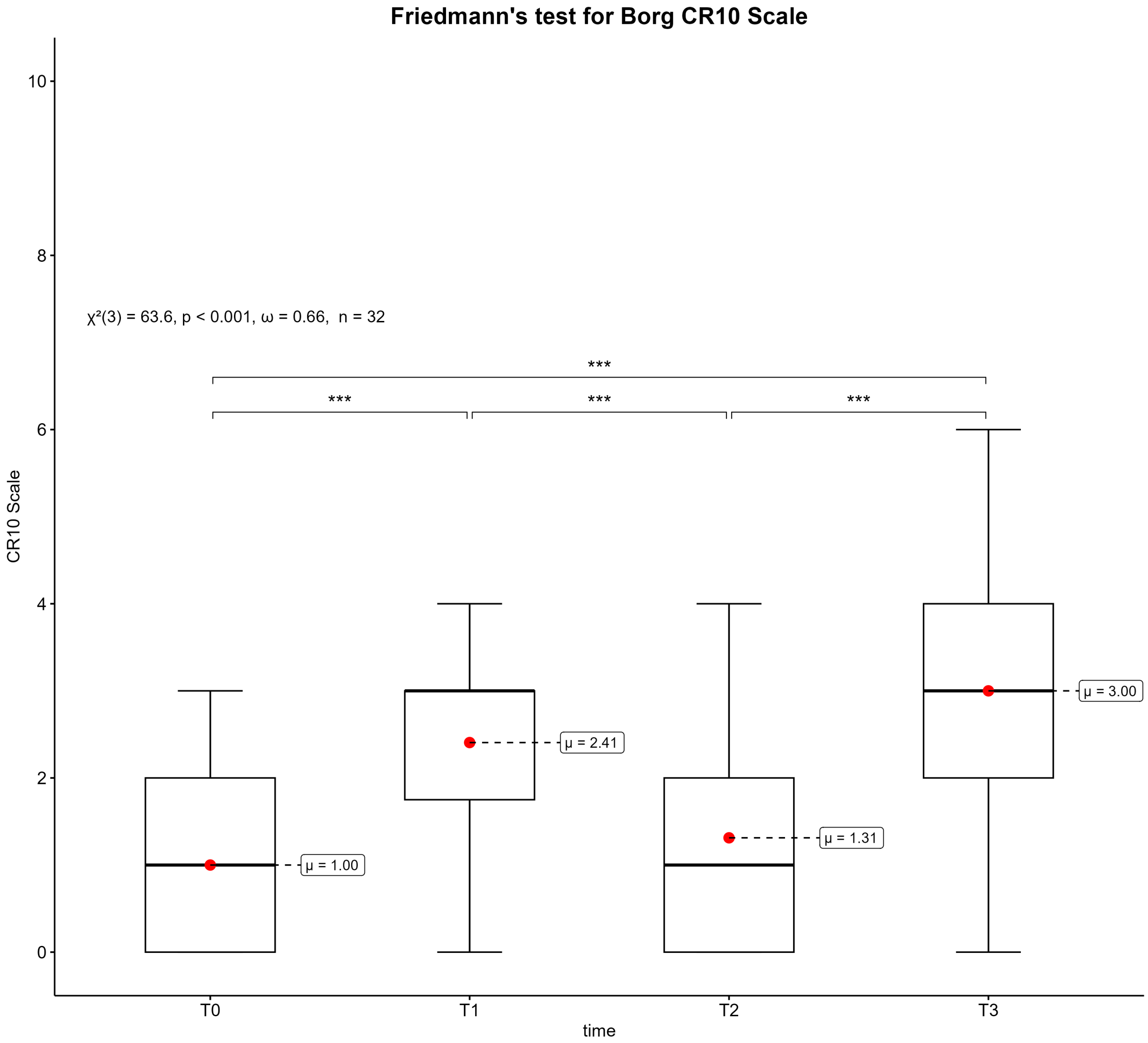

FIGURE 7
Box plots of the borg scale across the measurement points. T0 = baseline, T1 = after the first competitive video gaming session, T2 = after the ten-minute break, T3 = after the second competitive video gaming session. *: $p \le 0.05$, **: $p \le 0.01$, ***: $p \le 0.001$.

However, this study showed for the first time how esports athletes perceive physical burdens under realistic conditions in a controlled setup. This will contribute to the understanding of internal and external workloads associated with esports competition and training. In addition, the data sample size is strong for interventional esports research.

4.3 Practical implications

It is important to consider these results when structuring training programs for esports athletes. Regular breaks should be included in any esports training routine to avoid an increase in perceived physical burdens. In this study, passive breaks at least partially restored physical exertion and physical state. To enhance this effect and improve health and performance, physical activity should be a part of these breaks (42, 43). Even a 6-minute walk can improve cognitive function and subjective well-being in esports athletes (37).

Furthermore, body perception and perception of exhaustion should be trained. This could potentially empower esports athletes and coaches in load management and monitoring. In particular, coaches and health professionals should implement regular monitoring of these conditions in order to adjust training and health programs. As result, performance declines and health issues could be prevented or counteracted at an early stage. Additional objective measures, such as heart rate variability, eye tracking, or electromyography, could be beneficial as comparative parameters.

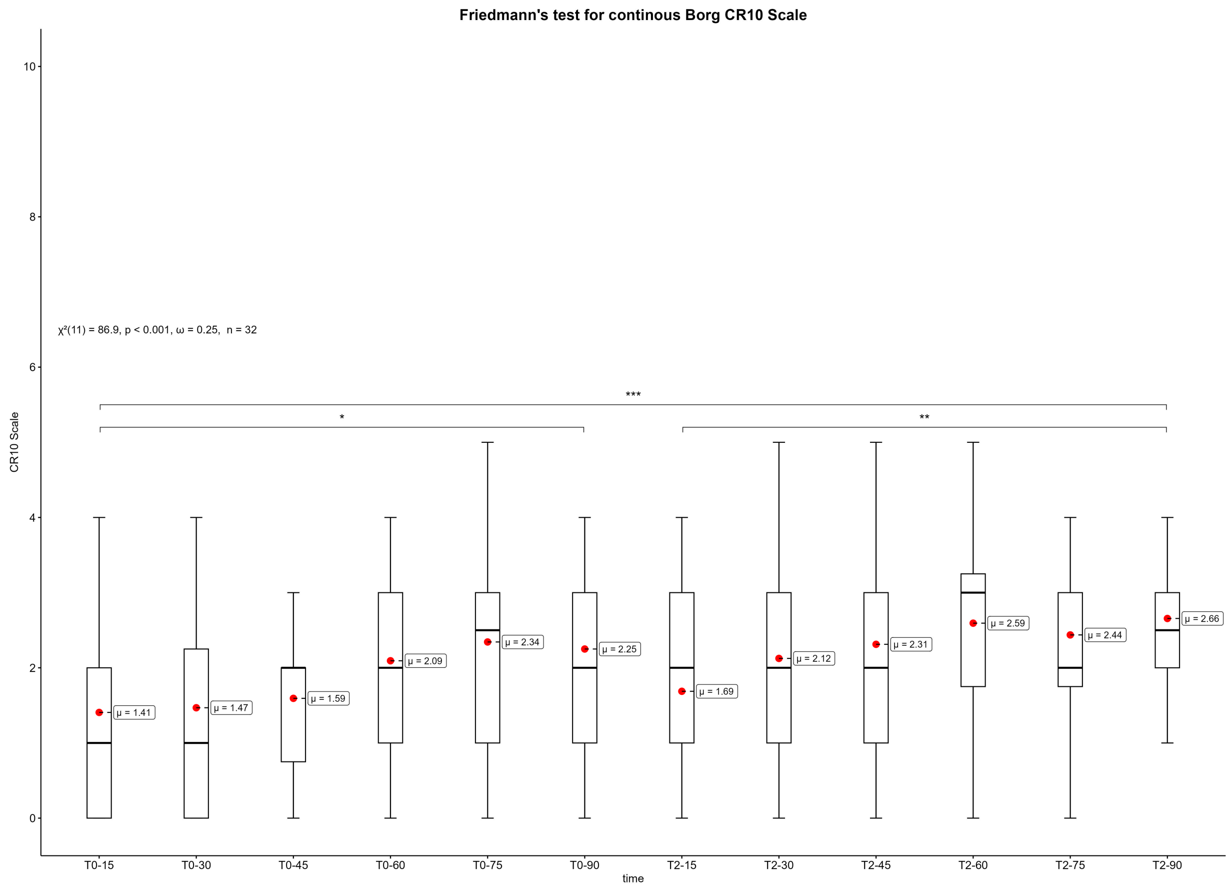

FIGURE 8
Box plots of the borg scale during the competitive video gaming sessions every 15 min. T0-min = first competitive video gaming session, T2-min = second competitive video gaming session. *: $p \leq 0.05$, **: $p \leq 0.01$, ***: $p \leq 0.001$.

5 Conclusion

In summary, competitive video gaming of 3–4 h can negatively affect the perceived physical exertion and the perceived physical state of esports athletes. A passive break may provide short-term regeneration but cannot fully restore. Over time and with a lack of observation, this could result in health and performance limitations. In addition, breaks should incorporate physical activity to mitigate the additional negative consequences of sedentary behavior, such as in esports. Moreover, physical exercise and body perception should be a crucial part of esports training. For practical implications, esports athletes are recommended to regularly monitor their burden and exertion, especially during competitive video gaming. This could lead to improve body perception, which is essential in preventing overtraining, overuse injuries, and burnout. Therefore, further research should focus on examining the validity and reliability of common measures of (perceived) exertion in esports. Additionally, more studies are needed to objectively investigate the physical burdens experienced during competitive video gaming.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/ **Supplementary Material**.

Ethics statement

The studies involving humans were approved by Ethical committee of the German Sport University Cologne. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CT: Conceptualization, Data curation, Project administration, Visualization, Writing – original draft, Formal Analysis,

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Investigation, Methodology, Resources, Validation, Writing – review & editing. MS: Data curation, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. IF: Conceptualization, Investigation, Methodology, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2024.1370485/full#supplementary-material

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Towards an automated approach for understanding problematic gaming

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Introduction: Video games have become increasingly popular worldwide, attracting billions of gamers across diverse demographics. While studies have highlighted their potential benefits, concerns about problematic gaming behaviors have also emerged. Conditions such as Internet Gaming Disorder (IGD) have been recognized by major health organizations, necessitating accurate diagnostic tools. However, existing methods, primarily reliant on self-report questionnaires, face challenges in accuracy and consistency. This paper proposes a novel technological approach to provide gaming behavior indicators, aiming to offer precise insights into gamer behavior and emotion regulation.
Methods: To attain this objective, we investigate quantifiable gaming behavior metrics using automated, unobtrusive, and easily accessible methods. Our approach encompasses the analysis of behavioral telemetry data collected from online gaming platforms and incorporates automated extraction of gamer emotional states from face video recordings during gameplay. To illustrate the metrics and visualizations and demonstrate our method's application we collected data from two amateur and two professional gamers, all of whom played Counter-Strike2 on PC. Our approach offers objective insights into in-game gamer behavior, helping health professionals in the identification of patterns that may be difficult to discern through traditional assessment methods.
Results: Preliminary assessments of the proposed methodology demonstrate its potential usefulness in providing valuable insights about gaming behavior and emotion regulation. By leveraging automated data collection and visualization analysis techniques, our approach offers a more comprehensive understanding of gamer behavior, which could enhance diagnostic accuracy and inform interventions for individuals at risk of problematic gaming behaviors.
Conclusion: Our findings demonstrate the valuable insights obtainable from a tool that collects telemetry data, emotion regulation metrics, and gaming patterns. This tool, utilizing specific indicators, can support healthcare professionals in diagnosing IGD and tracking therapeutic progress, potentially addressing challenges linked to conventional IGD assessment methods. Furthermore, this initial data can provide therapists with detailed information on each player's problematic behaviors and gaming habits, enabling the development of personalized treatments tailored to individual needs. Future research endeavors will focus on refining the methodology and extending its application in clinical settings to facilitate more comprehensive diagnostic practices and tailored interventions for individuals at risk of problematic gaming behaviors.

KEYWORDS
video games, Internet Gaming Disorder, gamer behavior, telemetry data, emotional states

1 Introduction

Video games are a major human activity that, in the last decades, have become increasingly more complex, diverse, realistic, and socially interactive, and are played by billions of people across geographical areas, cultures, and demographics (1). A recent report in Europe (2) concludes that: (i) 53% of the population aged 6–64 plays video games; (ii) games are played by more than two-thirds of children and adolescents; and (iii) a substantial number of adults also play games. The average age of gamers is 32 years old, and 74% play at least one hour/week, 17% one hour/month, and 9% once a year, and the average playtime is 8.8 h per week (2).

Over the past years, several studies have been undertaken to analyze the benefits on an individual's physical, mental, and social well-being (3–5). Some studies suggest that video games enhance cognitive abilities (6), improve socialization, provide stress relief, can have an educational value (7), can help gamers improve problem-solving skills, and can improve hand-eye coordination and fine motor skills (8).

Nevertheless, some problematic gaming behaviors have emerged, and the use of video games can have adverse effects related to depression, aggression, and physical health problems (9–12), pathological and even addictive (13–15). This problematic usage of video games can be associated with some factors. For example, some game genres have been associated with a higher prevalence of addictive behaviors, such as massively multiplayer online role-playing games, first-person shooters, and real-time strategy games/Multiplayer Online Battle Arena (MOBA) (16). On the other hand, various studies have yielded conflicting results regarding the relationship between gaming time and problematic gaming behavior. While some research suggests a link between increased gaming time and addiction [e.g., (17)], other studies have found contradictory evidence [e.g., (18)]. The recent international policy decisions evidence an attempt to resolve the scientists' uncertainties regarding the consequences of video game use (19, 20).

Due to the emergence of these problematic gaming behaviors, a disorder related to video game addiction emerged in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), in 2013, in the section of conditions for future study to motivate discussion and research (19). This disorder, named Internet Gaming Disorder (IGD), can be diagnosed using a list of nine diagnostic criteria, requiring evidence of at least five symptoms over a period of at least 12 months. Although the duration may be shortened in cases of severe symptoms that meet all diagnostic requirements (19). The severity of IGD can range from mild to severe, and it can affect people of all ages, although it is more common among younger individuals. Some examples of these criteria are withdrawal symptoms, constant preoccupation with video games, loss of interest in other activities, and lying/deceiving people or health professionals about the time spent playing, among others.

Additionally, the World Health Organization (WHO), five years later, also recognized Gaming Disorder (GD) in the International Classification of Diseases (ICD-11) and classified it as behavioral addiction related to video games (20). GD is characterized by a pattern of continuous or recurrent gaming behavior manifested by three symptoms: lack of control over gaming habits, prioritizing gaming over other interests and activities, and continuing to play games despite negative consequences. This pattern of gaming behavior may result in significant impairment in personal, social, educational, or occupational areas of functioning (20). The severity of IGD can range from mild to severe, can affect people of all ages, ethnicities, educational levels, or geographical distribution. According to Stevens et al. (21), the worldwide prevalence is 3.05%, while in Europe, it ranges from 0.8% to 11.8% (22).

Mental health professionals typically diagnose IGD using criteria outlined in the DSM-5 or the ICD-11, which requires careful assessments by therapists (23), and a range of factors need to be considered, such as severity, duration, and consequences of the gaming behavior, as well as any co-occurring mental health issues and family environment. Currently, to diagnose this disorder, self-report questionnaires are used as part of the assessment process and typically use a combination of clinical interviews, assessment tools, and other sources of information, such as reports from family members or close friends, medical records, and behavioral observations (23). Several self-report questionnaires have been commonly used in research and clinical practice to assess IGD (24), namely, IGDS9-SF (Internet Gaming Disorder Scale–Short-Form) (25), AIGDT-10 (26), video game addiction test (27), and Gaming Addiction Identification Test (GAIT) (28). Some tools, such as IGDS9-SF, are based on criteria like those found in the DSM-5, while others have unique criteria. The scoring and interpretation of the results may differ from one tool to another, which could impact how clinicians or researchers assess the severity of IGD (25) and can provoke significant differences in prevalence rates, diagnostic accuracy, and comparability of research findings across studies (29). Additionally, the self-report approaches have unavoidable limitations, namely, biased recall, denial/defensiveness, and lack of insight (23, 24). For instance, they are inaccurate as subjective responses of the gamer hardly capture the real gamer behaviors, as they may not remember or not mention some relevant information (e.g., year playtime, last week playtime, emotional states). A recent survey (24) underscores the ongoing uncertainty and a lack of consensus within the research community regarding the best practices for screening and assessing IGD. Researchers and clinicians continue to work towards establishing a consensus on the criteria used for screening and diagnosing IGD and develop a comprehensive standard assessment approach that considers the multidimensional nature of gaming behavior and its associated factors (24). Nevertheless, researchers and mental health professionals are also exploring alternatives to traditional assessment methods to improve the accuracy and validity of the diagnosis of IGD and to be used in conjunction with other clinical assessments and observations.

While recent research has suggested a limited influence of the time spent playing video games on overall well-being (30), it remains crucial to obtain precise insights into gamers behavior, emphasizing the characteristics of their gameplay experiences, in-game events, and the specific gamer profiles for which effects may differ (31) and emotion regulation remain crucial for understanding IGD (32, 33).

Nowadays, large volumes of game data are recorded daily through game telemetry that uses instruments and sensors to collect real-time data in video games (34, 35) including data related to the game, and events in which the gamers participated, and the actions they performed throughout the game. This data is commonly used in game design helping designers to understand how gamers interact with the game, which can help them make informed decisions about game usability, playability, and difficulty levels (36). In esports – defined as a sport mediated by an electronic apparatus, where the player intentionally and competitively plays video games, involving spectators, organizations, tournaments, and other infrastructures necessary for the execution and broadcast of a sport (37); telemetry data is especially valuable for analyzing the performance of gamers and teams, as it can provide insights into gamer behavior and help coaches and analysts improve performance and decision-making in real-time during tournaments and matches (1, 38). Beyond these purposes, it can potentially help analyze the gamer from other perspectives and help health professionals detect problematic gamer behaviors (39, 40). However, its potential to help analyze problematic gaming behaviors remains underexplored. A recent study (31) integrated in-game events and gamer behaviors with psychological measures captured with self-reported ratings to examine the relationship between the time spent playing video games and overall well-being.

Another essential component is understanding gamer's behavior based on their emotional functioning. Recent studies reveal that gamers with lower self-control, characterized by difficulties in regulating emotions, behaviors, and impulses, tend to exhibit a heightened motivation for video gaming, positively correlated with IGD (33, 41). Understanding how the criteria of IGD relate to emotional states is essential for accurate diagnosis and assessment (32). It provides insights into how gaming impacts emotional regulation and deepens our comprehension of the emotional functioning of gamers with problematic behaviors. This could help to understand the transition from regular to problematic behaviors and inform interventions focused on healthier ways to cope with emotions.

Our work introduces a novel method based on players' gaming data for helping healthy professionals in diagnosing IGD, specifically telemetry data, and emotion regulation data from online gaming platforms, and video data. This approach, which includes precise metrics and visualizations to analyze player gaming behaviors and emotional states, is important to assist health professionals in identifying specific diagnostic criteria of IGD, such as time spent playing and emotional fluctuations. By addressing some of the challenges associated with traditional IGD assessment methods, our research could have an impact on the field.

2 Methods

In this section, before detailing the proposed method, we explain how our methodology can be integrated into an existing IGD intervention protocol to illustrate its practical application by health professionals.

2.1 Proposed method and intervention protocols of IGD

Our ourk aims to develop tools that could be used in current intervention protocols, such as one of the most widely used and researched interventions for IGD, the cognitive behavioral program PIPATIC (Programa Individualizado Psicoterapéutico para la Adicción a las Tecnologías de la información y la comunicación) (23, 42).

In short, generally at the beginning of the treatment, the therapist conducts an assessment of the patient, consisting of questionnaires (such as IGDS9-SF (25), for IGD diagnosis), interviews, among others, to understand the patient's life history, symptoms, and diagnosis. The professionals and the patients meet every few days or weeks, where therapists monitor their patients' progress and symptomatology with questionnaires or follow-up questions. In the case of gaming addiction treatment, monitoring the progress helps the therapists understand the extent of gaming behavior since the last session, the impact of gaming on daily activities, and the patients' emotional state. Initially, sessions are scheduled more frequently, typically on a weekly basis, and as treatment progresses, sessions may gradually be spaced further apart.

By leveraging the proposed tools, clinicians can conduct thorough assessments, monitor patients' progress, and deliver more targeted interventions for individuals seeking support for gaming-related concerns. For instance, these technological solutions could enable therapists to analyze the historical gaming behavior of patients (gamers) during initial consultations. By providing access to historical data, therapists can gain insights into the patients' gaming patterns, including frequency and duration of gaming sessions. This will facilitate the initial diagnostic process and help therapists identify potential signs of gaming disorder.

Moreover, it analyzes emotional fluctuations to provide relevant information for proper diagnosis and therapy monitoring. Hence, we also gathered data on emotion from video faces in which the gamers show their faces during the game and transform them into interpretable features.

Additionally, in each therapy session, it is crucial for therapists to review the patients' most recent gaming activity. Therefore, the inclusion of indicators, measurements, and visualizations will allow therapists to review the gaming activity and the session intensity from the last consultation (some days or weeks ago), as well as the emotional fluctuations during the week. This monitoring capability will enable therapists to assess changes in gaming behavior over time and could inform treatment planning and adjustment.

Furthermore, the designed visualizations and indicators aim to provide valuable support to the questions of one of the approaches followed in clinic practice, such as those from the self-report questionnaire IGDS9-SF. Analyzing, for example, the evolution of gaming time, we can determine if gaming has become the

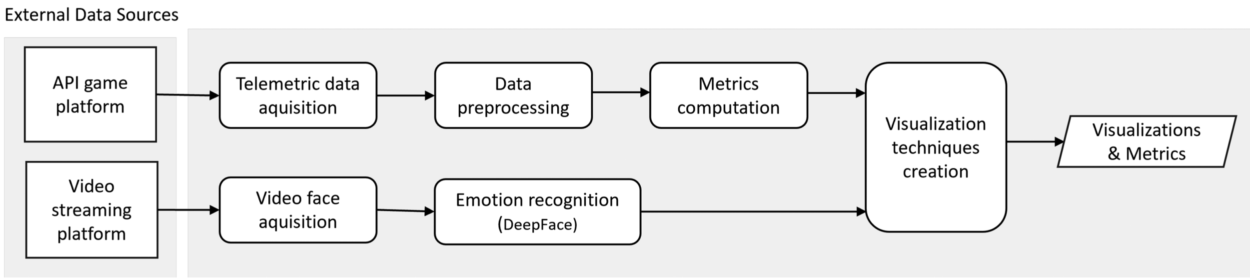

FIGURE 1
Steps of the proposed method.

dominant activity in the daily life of the patients or if they have given up other activities due to gaming, which is one of the nine diagnostic criteria of the DSM-5 (19). Following this, the therapists can identify potential inconsistencies between the responses provided in the questionnaire and the actual reality observed through telemetry and emotion analysis. These disparities may relate to additional diagnostic criteria outlined in the DSM-5, such as deceiving family members or therapists about gaming duration. For example, the patients' diminished perception of time could elucidate the disparity between questionnaire responses and telemetry data, indicating that the gamer may be unaware of the duration spent gaming.

In conclusion, the proposed solution, explained in the following section, is based on the definition of those metrics and visualizations, their usability, and their direct application to the main IGD diagnosis tool, the IGDS9-SF questionnaire.

2.2 Methodology

The proposed approach investigates quantifiable gaming behavior metrics using automated, unobtrusive, and easily accessible methods. Our approach encompasses analyzing behavioral telemetry and facial expressions, aiming to identify gamers' behavior patterns and examine correlations with IGD. We propose to innovate by exploring telemetry data collected from online game platforms to provide objective in-game gamer behavior, a historical view of gaming behavior, and precise insights into gamer behavior to discover or corroborate patterns of behavior that may otherwise be difficult to recall or identify; and provide data that could be correlated with other measures like, gamer emotions automatically extracted during the game. To accomplish the objective of identification of emotional states, our approach involves examining gamers' facial expressions during gaming sessions. These measures will also correlate with gamer behaviors and events derived from telemetry data. This will help elucidate how in-game actions are associated with emotional responses, clarifying the relationship between gamer emotion regulation and IGD.

The proposed method follows a methodology based on the Knowledge Discovery process through game data and gamers' video faces (1) and comprises several steps (see Figure 1), namely Telemetric data acquisition, Video face acquisition, Metrics Calculation, and Emotion recognition and the output that are the Visualizations and metrics.

Our approach prioritizes a user-centric design[1] to address the needs of healthcare professionals. Moreover, our team includes a Clinical Psychologist who works with gaming-related issues in clinical and research settings, ensuring a comprehensive understanding of their needs. She is also the coordinator of the Social Responsibility and Health Department, and of the Research Area at the Portuguese Esports Federation (FPEsports),[2] and she is also a gamer. She played a crucial role in defining attributes, validating metrics, and analyzing the visualizations during the method's phases. Leveraging her firsthand gaming experience, she provided valuable insights that enriched the design process and ensured that the tools effectively meet the needs of healthcare professionals.

The main steps shown in Figure 1 involved in managing and utilizing gaming telemetry and video data for analysis and decision-making purposes (1) were the following:

- Telemetric data acquisition and Video face aquisition: Firstly, it is essential to select the information needed to collect and define objective measures (metrics or indicators) that can be extracted from the data to quantify specific aspects of gaming behavior, such as the number of matches per month. It is crucial to analyze the various possible external sources to gather the data within a game environment, including player interactions, in-game events, match dates, or video recordings.
- Data preprocessing is an important step in the data processing pipeline, involving several tasks to ensure that the raw data collected is clean, accurate, and ready for analysis or for the Metrics calculation step. This can involve cleaning and filtering the data to remove errors, missing data, outliers, or irrelevant information (1). Also, this step is responsible for the data storage in databases or data files, locally or in the cloud.

[1]https://www.interaction-design.org/literature/topics/user-centered-design
[2]https://fpesports.pt/

- In the Metrics computation and Emotion recognition phases, we identified relevant measures from the telemetry game data and gamers' video faces that are indicative of gamer behavior and developed the respective calculation methods using statistical analyses and related techniques. The selection of these measures was based on their relevance and predictive power and may include variables such as total gaming duration, frequency of specific in-game actions, number of matches per day/week/month/weeks/year, and emotional states experienced during gaming sessions. To identify the emotional states experienced during gaming sessions (e.g., anger, fear, neutrality, sadness, disgust, happiness, and surprise) we analyzed gamers' video facial expressions using the DeepFace software.
- Visualization techniques creation. To enable the extraction of insights and patterns from the processed data and to gain a deeper understanding of gamer behavior and correlate some game events with emotional responses during gameplay, it is important to create visualization techniques, such as charts, graphs, and tables. These visualizations represent the findings in a meaningful and accessible way in order to help health professionals interpret the results and derive actionable insights.

Concerning the analysis of the various possible external sources to gather the data within a game environment, our method can be applied to any video game chosen. Nevertheless, the game genre and the game must be chosen to ensure the relevance and effectiveness of the data collected for analyzing gaming behaviors, particularly those related to IGD, and it is important to follow these guidelines:

1. Choose the game genre based on their relevance to IGD: a recent study (16) reported that playing massively multiplayer online role-playing games, first-person shooters, and real-time strategy games/Multiplayer Online Battle Arena is associated with more time spent gaming and higher endorsement of IGD symptoms.
2. Choose popular and widely played games. Popular games are more likely to attract gamers and increase engagement during gaming sessions.
3. Choose games with supportive and accessible communities open to research collaboration.
4. Prioritize games for which the gaming platforms provide services to access telemetry data with automated and publicly accessible methods.

In the following subsections, we provide a detailed account of the data acquisition and preprocessing stages, definition and calculation of the metrics, and illustrate the application of our method using a specific game and data from four gamers. These use cases showcase the metrics and visualizations, and demonstrate how our method is applied.

2.2.1 Telemetric data acquisition and video face aquisition

This step of the proposed process corresponds to selecting the information needed to collect and define objective measures (metrics or indicators). The data we want to gather is related to telemetry data, such as the list of matches played by the gamer. We want to extract information that can be useful to determine how many matches s/he played in the last days and their duration. Additionally, we process video information to extract gamers' emotional states, such as anger, happiness, or surprise. This section starts with an explanation of the chosen game, followed by an explanation of how we extracted data from the different environments: gaming and video data.

We chose Counter-Strike[3] (CS) from Valve following the exposed guidelines, namely it is a game of the family of first-person shooters, and CS is a game for which automated and open services exist to access telemetry data, and as a popular and widely played game, it was easier to find public face recordings. Shortly in CS matches, each game consists of multiple rounds where teams (with five gamers each) compete against each other. The number of rounds varies depending on the game mode being played, and in the classic mode, which is the most common, a match typically comprises 30 rounds. Each round typically lasts around 1 min and 45 s to 2 min, contributing to a total match duration of approximately 30 to 45 min. The team that wins 16 rounds first is declared the overall winner of the match.

In order to demonstrate the application of our method and better understand the proposed metrics and visualizations, we extracted information from four gamers as use cases. The four gamers, two amateur (G1 and G2) and two professional, G3 and G4 (e.g., earn money from donations during their broadcasts and devote most of their time to gaming), were chosen to provide a diverse perspective on gaming behaviors across different skill levels.

It is worth noting that we only used publicly available gaming data from both platforms, ensuring the confidentiality of players' information and the protection of their privacy in accordance with best practices. This approach respects the principles of fair use and promotes the public interest.

Telemetric data acquisition. We initially considered Steam[4] as a primary source for telemetry data due to its popularity among gamers, particularly for playing CS. However, it lacked player-specific information and statistics. One valuable data source explored was the Steam login history,[5] which could provide insights about gaming time, but access to this data requires gamer permission, and one fundamental requirement of our work is the open accessibility to the telemetry game data. We decided to use the FACEIT[6] platform to extract the telemetry data for the four gamers. Like many online gaming platforms, FACEIT typically provides information such as a gamer's username, gaming statistics (e.g., win/loss ratio, kill/death ratio), match history, and achievements. However, we do not have access to personal information except some basic profile information that the player chooses to share publicly. This

[3]https://www.counter-strike.net/
[4]https://store.steampowered.com/
[5]https://help.steampowered.com/en/- accountdata/SteamLoginHistory
[6]https://www.faceit.com/

platform provides all the necessary information through their public API[7] and includes information about gamers, matches, and tournaments. For each gamer, we collected information about all the matches between January 2021 and December 2022, namely the start time and duration of each gaming session (*starting and ending datatimes*) allowing us to calculate the duration of matches, the *day part* and *weekday* of every match, the continued *gaming time*, and other player metrics. In addition, we also gathered in-game actions performed by the player aggregated in detailed match statistics, for instance, the number of *kills*, *deaths*, *assists*, or *kill-death ratio*, among others.

The rationale behind acquiring two years of historical data stems from the crucial role of seasonality. This duration enables us to thoroughly examine and explain individual behaviors during particular periods throughout the year. For instance, we can discern patterns such as fluctuations in gaming activity during holidays or exam periods for a student gamer, thereby providing valuable insights and justifications.

Video face aquisition. Furthermore, Twitch[8] was utilized to obtain live-streaming video content, particularly from the two professional gamers, for subsequent analysis and emotion extraction. Twitch is a widely-used online platform, attracting a diverse audience of active gamers who stream digital video broadcasts and passive viewers. Each video was selected based on specific criteria, ensuring clear frontal visibility of the face, proper lighting conditions, and close camera proximity. This selection process aimed to streamline the subsequent video analysis phase. For the two amateur gamers, it was not possible to obtain this data.

To identify the emotional states experienced during gaming sessions (e.g., anger, fear, neutrality, sadness, disgust, happiness, and surprise) we analyzed gamers' video facial expressions using the DeepFace software library.[9] DeepFace, developed by Facebook, is a system designed for facial analysis and emotion recognition tasks. It leverages deep learning techniques to accurately detect faces, estimate facial attributes, and recognize emotional states from images or video frames. For the two professional gamers, we collected several videos containing several consecutive matches (5 matches on average and with a duration of 4–5 h) during 2 weeks. This data range is different from telemetry data because it is not possible to know the actual date of the videos loaded more than a month ago. The Twitch platform only informs how many months ago the video was uploaded.

2.2.2 Data preprocessing

The data we collected from the mentioned platforms did not require a cleaning process due to the good state of the main data sources from FACEIT and Twitch.

[7]https://developers.faceit.com/docs/tools/data-api

[8]https://www.twitch.tv/

[9]https://pypi.org/project/deepface/

2.2.3 Metrics computation and emotion recognition

In this section, we present the metrics computation phase of the proposed method derived from the raw data collected from the FACEIT and DeepFace video analyses.

Telemetry gaming data: As noted earlier, our data extraction process relied on FACEIT to obtain information about gamers and their gaming activities. We extracted over 50 variables (features) from this platform, with key variables including *started_at* and *finished_at*, and the *match_id*. Additionally, we extract some important gaming activities, namely *health_points* and if the gamer *is_alive*, from player-frame granularity; and *tick* and *attacker* from kill granularity.

These raw data variables were aggregated and combined to create more intricate features that provided additional value. Below, we explain the definition of the most important:

- A session represents a series of consecutive matches played by a gamer, starting when they begin playing and ending when they stop. Consecutive matches are those played within 30 min of each other, determined based on the team gaming experience and the distribution of the *time between matches* variable (60th percentile). Each match belongs to only one session, but multiple matches may be part of one session. Multiple sessions can occur within a day.
- Gaming time refers to the total duration of a gaming session, which includes the time between the first and last match.
- Based on the match date and time, we defined two new features: day part and weekday. *Day part* can take three values: morning (from 6 a.m. to 1 p.m.), afternoon (from 2 p.m. to 9 p.m.), and evening (from 10 p.m. to 5 a.m.). *Weekday* indicates if the match is played during the midweek (from Monday to Friday) or during the weekend (Saturday and Sunday).

From these features, we define the metrics presented in Tables 2–4. The most relevant is the amount of time spent gaming each month (*Avg played hours per month*), the number of matches played per session (*Avg matches per session*), and the average duration of each gaming session (*Avg hours per session*).

Video emotion data: We examined the emotions per second in the numerous videos of G3 and G4, capturing the frequency of each emotion experienced, including anger, happiness, fear, sadness, disgust, surprise, and neutral. To improve clarity and facilitate comprehension of the gamers' emotions, we opted to smooth the trends of each emotion by calculating the median of the previous five seconds for each instance. This approach facilitated the identification of emotions such as happiness or anger, making them more discernible.

Furthermore, we aim to understand the dynamic changes in emotions throughout a gaming session. To achieve this, we correlate in-game telemetry data with emotions extracted from video analysis. The objective is to examine the player's emotional state during pivotal moments such as kills, deaths, and the initiation or conclusion of rounds. An illustrative example of this analysis is depicted in Figure 2, where it is evident that G4 experienced anger upon eliminating two opponents but exhibited fear and sadness at the round's conclusion. This correlation

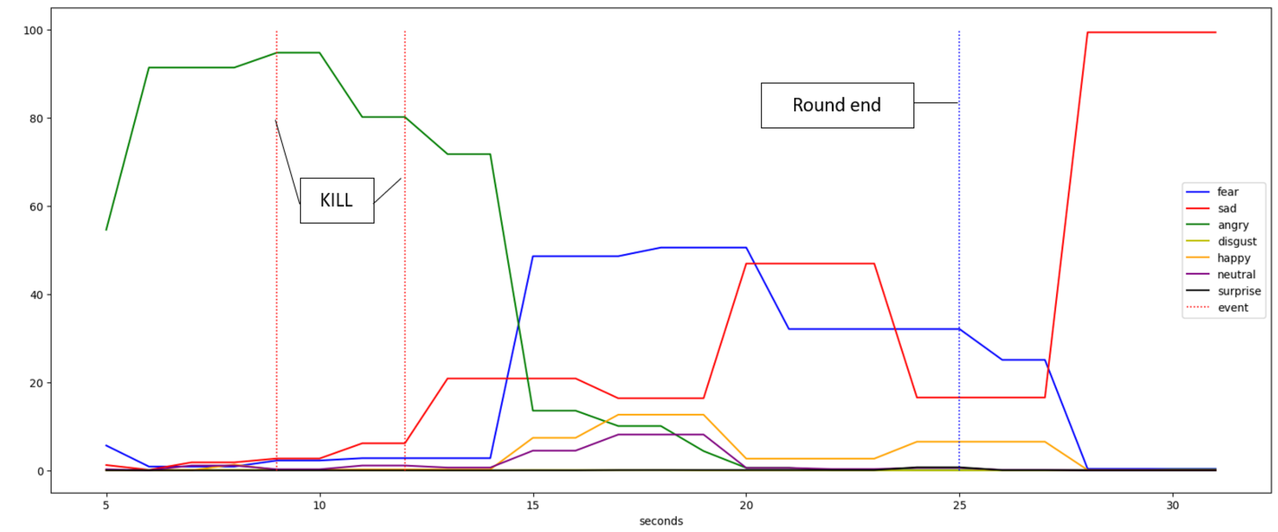

FIGURE 2
The percentage of time experienced by Gamer 4 for each emotion per second during one round, highlighting three key events: two kills and the end of a round.

TABLE 1 Median emotion level felt during each event.

Event	Angry	Disgust	Fear	Happy	Sad	Surprise	Neutral
Kills	13.54	0.05	11.23	2.14	8.92	0	0.63
Deaths	22.56	1.28	17.47	2.39	27.86	0.04	2.78
Round ini	37.83	0.02	36.58	0.04	17.75	0.02	2.4
Round end	0.07	0	32.04	2.65	46.9	0.06	0.3

underscores the need for further investigation in future studies. While this approach, involving the analysis of emotions by player, event, round, and match, is intricate and challenging to execute, one viable solution is to analyze the median emotional response of players across events and matches, as demonstrated in Table 1. This table displays the median emotions experienced during instances such as kills, deaths, and the start and end of rounds within a single match. In kills and deaths events, emotions are calculated by taking the median values (in percentage) of emotions 3 seconds before and after the event.

After conducting several tests, we determined that calculating the average emotion experienced throughout the match yielded the most effective results. This approach involved computing the mean of each emotion across the entire duration of the match, disregarding specific events. As shown in Figure 3-left, our analysis showcases the emotional experiences of G3 across five distinct matches within a single session. It provides a comprehensive view of the overall emotions experienced by gamers throughout each match, disregarding any sudden emotional changes that may occur during gameplay. On the other hand, it is crucial to understand whether external factors or events, unrelated to the game, influence the players' emotions, such as household or professional environments. Therefore, we have created a chart that shows the gamer's emotional state at the start (first 5 min) and at the end (last 5 min) of the match, as illustrated in Figure 3-right. We detail this type of visualization in the next section.

2.2.4 Visualization techniques creation

This phase of our method involves creating appropriate visualization techniques to represent the processed data in a meaningful and accessible manner. We developed various charts, graphs, and tables, which will be presented in the subsequent section. As previously mentioned, the visualizations were selected in collaboration with a healthcare professional to ensure that the tools effectively meet their needs.

3 Results

In this section, we analyze how each developed metric and visualization can assist therapists in the diagnosis of IGD. It is organized into three subsections. The first focuses on the initial stage of the treatment, where the therapist starts knowing the patient, as explained in Section 2.1. To achieve this, the therapist needs to understand the historical behavior of the gamer. The second section, recent gaming behavior, involves monitoring the therapy and analyzing its effectiveness. Prior to each consultation, it is helpful to briefly review the patient's behavior in the past few days or since the last visit, including analyzing

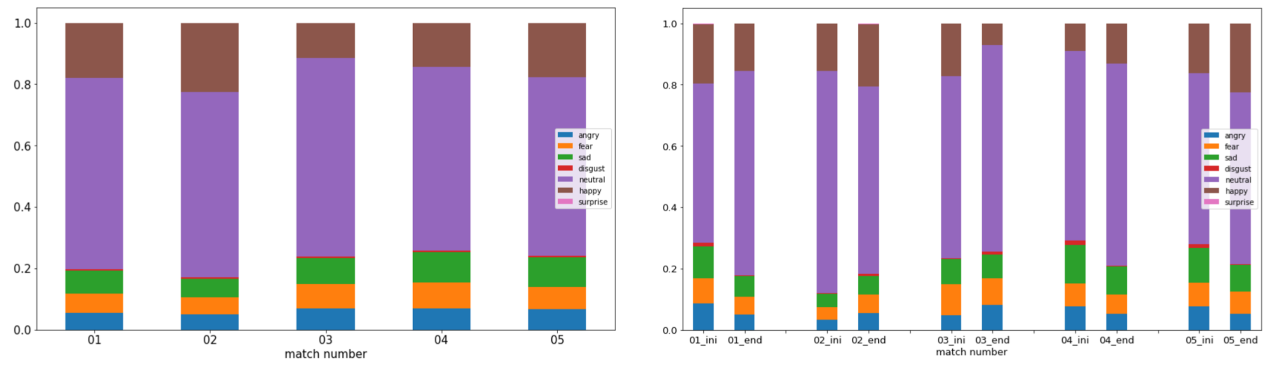

FIGURE 3
Percentual emotion average felt (left) during 5 matches separated by sessions and (right) on the first and last 5 min during 5 matches of G3.

gaming telemetry and emotions data. The last section, recent emotional behavior explains the metrics and graphs regarding emotional fluctuations that the therapists could explore just before each consultation.

3.1 Historical gaming behavior

The literature suggests that therapists must have a clear understanding of their patients' situations from the outset. This entails examining the duration of gaming sessions on a daily, weekly, and monthly basis, as well as identifying the specific times of day during which individuals typically engage in gaming activities. Additionally, is equally essential to assess potential disparities between weekend and weekday gaming behaviors. To accomplish this goal, we propose a set of indicators that can help understand the historical gaming behavior (Table 2), such as the *number of matches* or the *total hours played*. Also, the intensity can be analyzed through the *average hours per session* (all the games played with less than 30 min of difference between them) or compare the gaming behavior by weekday and part of the day.

The analysis of these indicators for the four gamers reveals that in 2021 and 2022, G1 and G2 (both amateurs) primarily played in the evening, possibly in their free time after school/work. These gamers seem to maintain their gaming pattern during the period of 24 months, without significant changes. The professional gamers, G3 and G4, had a more balanced day-part ratio, which was expected since its their job. Overall, the four gamers played approximately 75% of their games during weekdays (midweek hours accounted for 72% of the total week time) without significant changes between 2021 and 2022. Regarding the *average hours per session*, G4 seems to be an intensive player, as they appear to maintain a pattern of long gaming sessions (approximately an average of 4 h per session) during 2021 and 2022. The other professional player, G3, has doubled its playtime in 2022.

To facilitate the analysis of time spent playing in each part of the day, we developed the visualization shown in Figure 4-left. The bars corresponding to the morning hours played were minimal for all gamers; therefore, they were not represented in the graph. The data shown covers 24 months from January 2021 to December 2022. This graph corroborates Table 2, where G2 plays mainly in the evening. Typically, they spend 30 or more hours playing during the evening every month. However, they do not play in August, possibly due to vacation time. The evolution of the *average hours played per month* is relatively stable, except for the last months when they reduced the total playtime.

To explore variances in gaming duration between midweek and weekend sessions, we developed the visualization depicted in Figure 4-right. Once more, we can track the gaming behavior of G3. Throughout 2021, except for March, the average monthly playtime was around 27 h (see Table 2). However, in 2022, the playtime more than doubled, reaching 67 h. This substantial increase may indicate a shift in gaming behavior or a potential transition to professional gaming. Notably, there is one month where the player reduced gaming time, prompting further analysis into the underlying reasons. To investigate potential seasonal patterns, we constructed the chart depicted in Figure 5. This chart illustrates the total monthly gaming hours by year. Interestingly, a recurring pattern emerges where G3 pauses gaming activities every June. Furthermore, most yellow bars surpass their purple counterparts, indicating a substantial increase in gaming time during 2022.

To measure the gamer's intensity and an accurate overview of their gaming habits, we analyzed the duration of gaming sessions and developed the graphs shown in Figure 6. The blue bars indicate the number of monthly matches, while the green bars represent the number of gaming sessions played per month. If a gamer only plays one match per session, the blue and green bars will be of equal height. However, the bars will be significantly far apart if the gamer plays all the monthly matches in just a few sessions. Therefore, the greater the difference between the number of matches and sessions, the more intense the gamer's gaming behavior. For example, if we analyze the number of matches and sessions, we can infer that G4 is a very engaged gamer.

The information from the various visualizations (graphs and tables) can help the health professionals to conduct further analyses of the gamers. For example, G4 played 67 matches per

TABLE 2 Main telemetry metrics for the four gamers.

	G1		G2		G3		G4	
	2021	2022	2021	2022	2021	2022	2021	2022
General stats								
Number of played matches	320	402	570	499	488	1,178	805	1,009
Average match duration (min)	40	40	40	40	40	40	40	40
Total hours played	223	281	390	344	328	816	570	731
Total hours connected to FACEIT	252	316	438	389	375	967	699	892
Number of sessions played	170	227	314	273	253	410	151	193
Session stats								
Avg number of sessions per week	5.21	5.22	6.8	6.17	5.8	8.67	3.48	4.59
Avg number of sessions per month	17.1	20.82	26.58	23	21.25	34.25	12.58	17.82
Avg matches per session	1.86	1.77	1.82	1.83	1.93	2.87	5.33	5.23
Avg hours per session	1.47	1.39	1.4	1.42	1.48	2.36	4.63	4.62
Monthly stats								
Avg matches	32	36.55	47.5	41.58	40.67	98.17	67.08	91.73
Avg played hours	22.34	25.55	32.53	28.67	27.32	67.97	47.46	66.44
Avg matches during midweek	23	27.27	35.08	31.42	33	76.08	52	72.45
Avg matches during weekend	11.25	9.27	13.55	11.09	10.42	24.09	16.45	19.27
Avg hours played during midweek	16.14	19.17	24.28	21.56	22.31	53.12	36.89	52.65
Avg hours played during weekend	7.75	6.37	9.01	7.75	6.87	16.2	11.53	13.79
Weekly stats								
Avg matches per week	8.65	7.58	10.56	9.24	9.96	21.42	16.77	20.18
Avg played hours per week	6.04	5.3	7.23	6.37	6.69	14.83	11.86	14.62
Number of weeks played	34	46	49	47	44	49	44	44
Day part stats								
Avg daily morning hours	0	0	0	0	0.04	0.02	0.09	0.03
Avg daily afternoon hours	0.06	0.08	0.15	0.08	0.51	0.85	0.56	0.87
Avg daily evening hours	0.55	0.69	0.95	0.87	0.38	1.39	0.89	1.04
Morning matches percentage	0	0	0	0	0.05	0.01	0.06	0.02
Afternoon matches percentage	0.1	0.1	0.13	0.09	0.55	0.38	0.37	0.45
Evening matches percentage	0.9	0.9	0.87	0.91	0.41	0.62	0.58	0.54
Weekday stats								
Weekend matches percentage	0.28	0.25	0.26	0.24	0.26	0.22	0.22	0.21
Midweek matches percentage	0.72	0.75	0.74	0.76	0.74	0.78	0.78	0.79

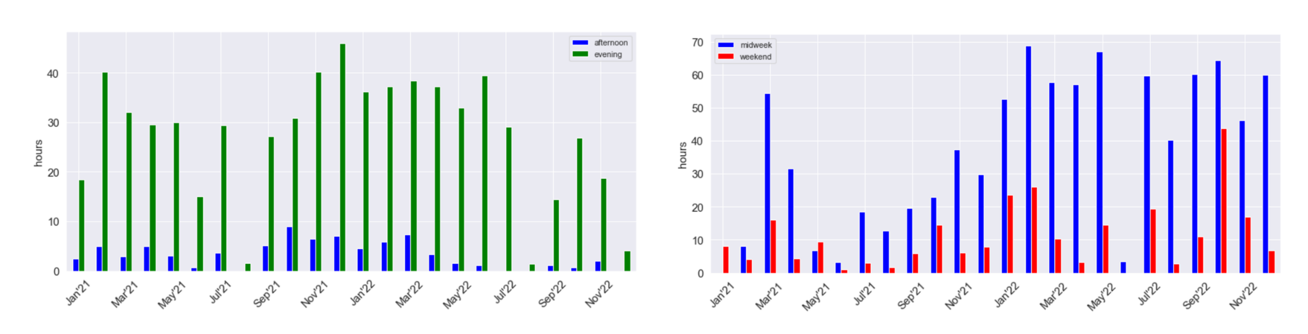

FIGURE 4
Total monthly hours played in the afternoon and evening by Gamer 2 (left) and during midweek and weekend by Gamer 3 (right) during two years.

month on average in 2021 and 91 in 2022, increasing by 35%. Nevertheless, the number of matches per session remained stable, around five, and the intensity stayed equal (see Figure 6-right). In contrast, G2's playing time remained stable from 2021 to 2022 (around 1.8 h), and their sessions on average took 1.4 h (1 h 24 min), less than half (see Table 2, Figure 6-left).

3.2 Recent gaming behavior

Monitoring patients weekly to follow their initial diagnosis is crucial. To assist therapists in this task, we created specific indicators for tracking their gaming habits between consultations. These indicators are intended to be presented to therapists before each

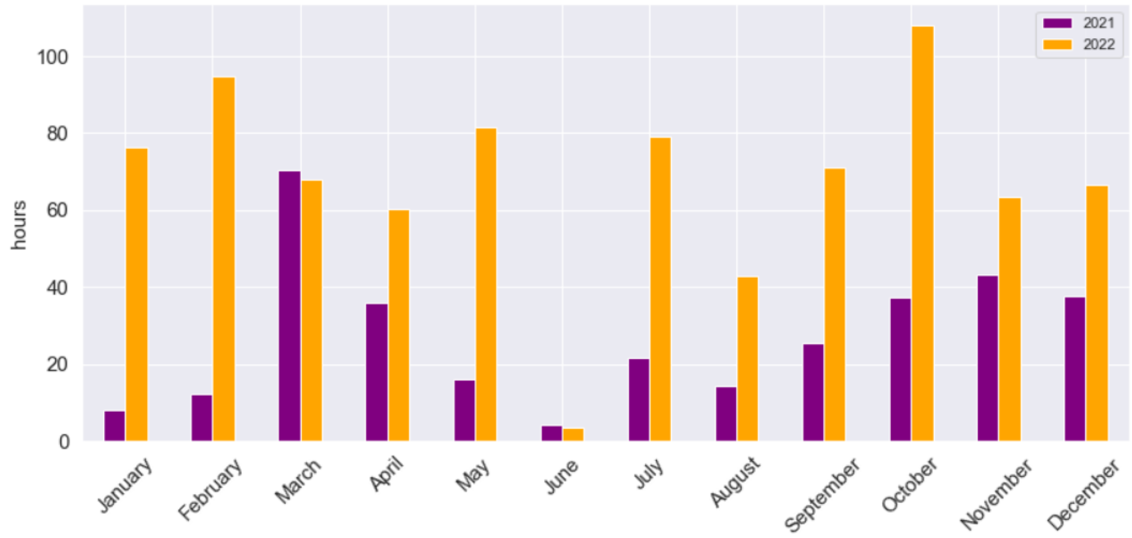

FIGURE 5
Total monthly hours per year for the Gamer 3.

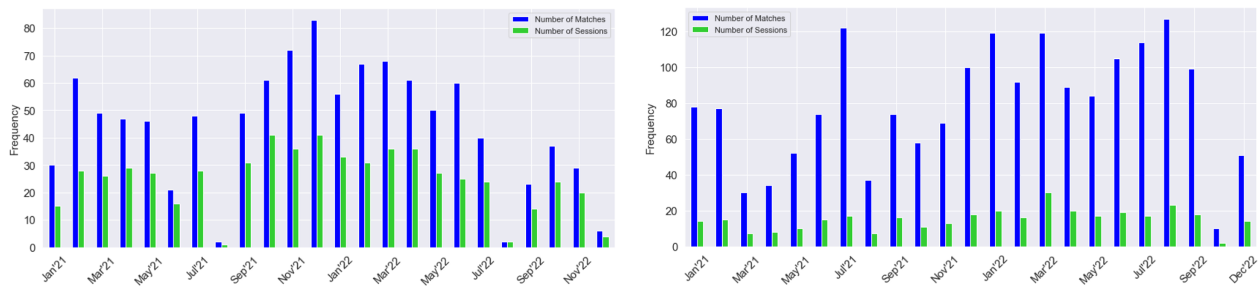

FIGURE 6
Monthly number of matches vs. number of sessions for Gamers 2 (left) and 4 (right).

TABLE 3 Metrics related to the gaming time during the last 7 days, compared with the previous week and month.

Time played	G1	G2	G3	G4
Total hours last 7 days	8.2	11.2	14	21.4
% Difference last week	52	72	−15	5
% Difference last month	−11	6	−39	−9

TABLE 4 Metrics related to the intensity and duration of the sessions during the last 7 days, compared with the previous week and month.

Intensity	G1	G2	G3	G4
Total sessions last 7 days	7	10	9	9
Hours/session ratio last 7 days	1.2	1.1	1.6	2.4
% Difference hours/session last week	9	−15	−43	−29
% Difference hours/session last month	−14	−27	−16	−43

session, offering insights into the patients' recent gaming behavior. The metrics available for therapists are presented in Table 3, as well as the values for the four gamers. The metrics include the *total number of hours spent in the past 7 days* and the *percentage difference compared to the previous week and month*. From the values we could infer that G1's gaming time has seen a notable increase of 52% over the past 7 days but decreased by 11% compared to the previous month, indicating a less stable trend in gaming behavior. For G2, we can identify an increase of 72% in gaming time over the past 7 days, while G3 decreased by 15% in playing time compared to the previous week and by 39% compared to the previous month. These changes could be used by the health professionals to further understand the recent behavior of the patients.

Furthermore, the therapists can also evaluate the frequency and duration of the gamers' sessions in the previous week (*total sessions last 7 days*) and the percentage difference compared to the previous week and month with the metrics presented in Table 4. From this information, an health professional could infer that G1 has been exhibiting an inconsistent gaming behavior lately. They played 7

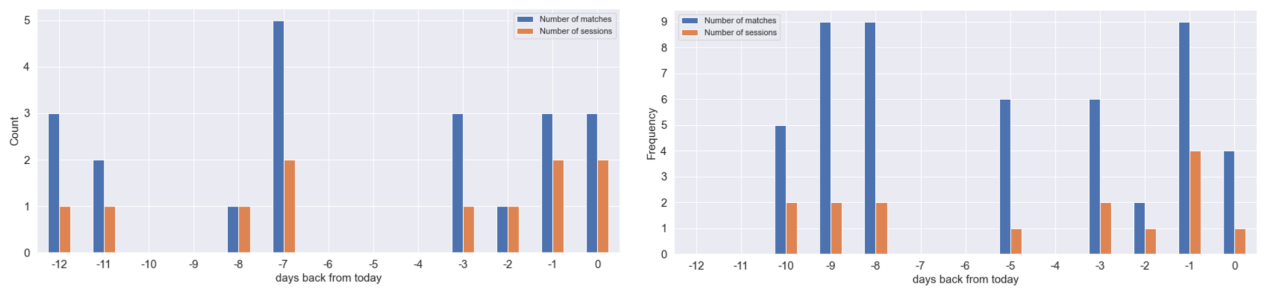

FIGURE 7
Daily number of matches vs the number of sessions during the last 2 weeks for Gamer 1 (left) and Gamer 4 (right).

times during the week, with a ratio of 1.2 hours per session, resulting in an increase of 9% compared to the previous week but a decrease of 14% compared to the previous month. On the other hand, for G2, G3, and G4, the therapists could infer that patients played less than their usual, showed by a decrease of hours/session compared to the previous week and previous month.

To complement the metrics information, we developed the plots presented in Figure 7 where the vertical axis displays the number of matches (represented by blue bars) and sessions played (represented by orange bars) per day, spanning from the current day to 12 days prior. As we saw in Figure 6, also in this figure, a wider disparity between the blue and orange bars suggests more intense gaming sessions. We can see that over the past 13 days, G4 engaged in 9 matches on three occasions, implying gaming sessions of over 6 hours per day (across 2 or 3 sessions), representing the days where they played the most. In contrast, G4 did not played for five days in the past 13 days, and only engaged in a session with two matches in one of the other days. On the other hand, G1 played only 3 matches on most days, equivalent to 2 hours per day, sometimes in more than one session. The gaming behavior of both gamers appears consistent across the two observed weeks.

3.3 Recent emotional behavior

To allow therapists to explore gamers' emotional fluctuations, we developed a pie plot (Figure 8) with the percentual average emotion felt by a gamer during the last 2 weeks. From the example in Figure 8, the therapists can see that G4 felt mostly negative emotions, namely angry, fearful, and sad, 41%, 21%, and 18%, respectively.

To understand the variation between matches and determine whether the emotions experienced are constantly present or it is only noticeable at certain moments, we developed the visualization in Figure 9-left, where the focus is on match-by-match emotional behavior, with the space between them being used to separate different sessions. Again, negative emotions, such as anger, fear, and sadness, appear to be predominant during every match of G4. However, there are some differences between sessions. Fear and anger are the most significant emotions in the first two (6 matches). Besides, in the rest of the sessions, anger became even more dominant, and sadness overtook fear in importance.

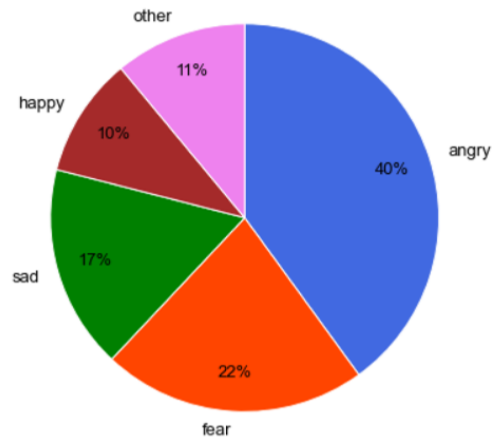

FIGURE 8
Percentual average emotion felt by Gamer 4 during the last 2 weeks.

Another important analysis is considering whether emotions change throughout a gaming match or are influenced by external factors. We designed the graph shown in Figure 9-right that can help to answer these questions. Just like in Figure 3-right, we can observe the emotions experienced during each match's first and last five minutes. Figure 9-right represents the last four matches analyzed in Figure 9-left. We can observe how the state of mind of gamers can change. For example, for gamer G4, as previously mentioned, anger is the most common emotion observed. Furthermore, it appears to increase as the match progresses. Anger levels are lower in the first five minutes than in the last five minutes. Conversely, sadness decreases toward the end of the match. Although happiness levels are low, they also seem to decrease at the end of some matches. Meanwhile, G3 shows a calm mood while playing, even happiness (see Figure 3-left).

4 Discussion

In this section, we discuss how clinicians can use the proposed method's results (metrics and visualizations) in conjunction with the nine answers to the IGDS9-SF questionnaire for patients that

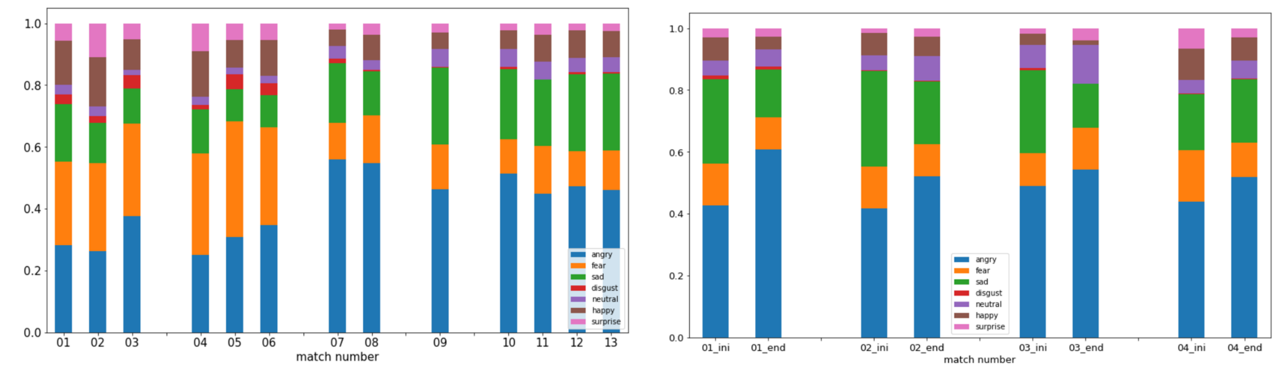

FIGURE 9
Percentual emotion average felt during (left) 5 matches of Gamer 4 and separated by sessions; and (right) on the first and last 5 min of each match during the last session (4 matches) of Gamer 4.

they suspect of problematic gaming behaviors. They already know what to look for and what relevant behavioral indicators to monitor. In particular, our approach will help clinicians to identify disparities between the metrics and visualizations and the responses provided by gamers to the questions within the IGDS9-SF questionnaire. Given the nature of the questions, it is important to note that while telemetry data and emotional states can provide important insights into gaming behavior, they cannot directly address the subjective experiences described in questions such as 1, 6, and 7. These questions delve into the individual's feelings, perceptions, and behaviors, which cannot be captured by those metrics and visualizations.

For example, in Question 1 ("Do you feel preoccupied with your gaming behavior?"), telemetry data might reveal extensive gaming activity, but it cannot directly measure the individual's sense of preoccupation with gaming. However, by examining trends in gaming behavior over time, therapists can better understand the extent to which gaming occupies the individual's daily life and assess whether this preoccupation aligns with the subjective experiences described in this question. For instance, observing whether gaming is becoming a primary daily activity of the gamer through the significant increase of the metric *last 7 days total hours* in Table 3.

Similarly, for Question 6 ("Have you continued your gaming activity despite knowing it was causing problems between you and other people?") and Question 7 ("Have you deceived any of your family members, therapist, or others because of the amount of your gaming activity?"), telemetry data and emotional states cannot provide insight into the individual's motivations or intentions behind their actions. Therefore, while telemetry data and emotional states can offer valuable information in assessing gaming behavior, they should be complemented with self-reported responses to understand the subjective experiences described in these questions. Next, we discuss the remaining six questions that can be supported by the metrics and visualizations.

Question 2: Do you feel more irritability, anxiety, or even sadness when you try to either reduce or stop your gaming activity?

We cannot directly answer this question using the proposed metrics or visualizations. However, we can suppose that if the gamer finishes a game session but shortly afterward starts playing again, it could mean that stopping was difficult, possibly accompanied by negative emotions, such as anger or even sadness.

The therapist can analyze the emotions at the end of each match or session and compare the emotional status evolution over several consecutive matches with the visualization in Figure 9-left. Also, s/he can compare the emotions at the first and last 5 min of each match and observe if the negative emotions have increased during the match (Figure 9-right). If negative emotions are greater at the end of the match compared to the beginning, it could possibly be an indicator of irritability or sadness. The therapist can also analyze the metrics *number of daily gaming sessions*, and recent gaming behavior indicators, such as *weekly playtime* (Table 3) and *weekly intensity* (Table 4) as they can be possible indicators of the difficulty in stopping.

Question 3: Do you feel the need to spend an increasing amount of time engaged in gaming in order to achieve satisfaction or pleasure?

The purpose is to assess whether the patient has developed a tolerance to gaming, which may result in increased time spent playing in order to experience satisfaction or excitement.

The therapist can analyze the time spent playing games, mainly if the patient is playing more frequently and for longer sessions, examining recent gaming behavior indicators, and if the time spent on in-game activities has increased or changed in the last few days. To achieve this, s/he can observe Table 3 to analyze if the *total gaming time* has increased regarding the previous week or month; and Table 4 to examine if the *duration of the sessions* is stable or has increased face to last week and month. Analogously, Figure 7 informs about the total number of hours and the intensity of the sessions. If these indicators reveal an increasing tendency regarding gaming time and duration of the sessions, it can mean that the gamer needs to spend more time playing video games and could be developing tolerance to gaming.

Question 4: Do you systematically fail when trying to control or cease your gaming activity?

One way to analyze the difficulty of stopping gaming is to observe when the gamer engages in several gaming sessions daily and analyze the total number of hours dedicated to gaming during the last days.

To achieve this objective, the therapists can examine the metrics *total hours in the last 7 days* and the *ratio of hours/session* in the last week (Tables 3, 4). If gaming time and intensity increased during the last week or month, it could indicate that the gamer is not achieving the goal of ceasing gaming activity. Additionally, the therapist can evaluate the relationship between the number of daily matches and the number of daily sessions in Figure 7. If the gamer usually plays more than one session, plays every day, or whose sessions are longer, it could be an indicator of problems with stopping gaming activity.

The therapist can also obtain a global view by analyzing the total time spent per month, by midweek/weekend and by afternoon/evening in Figure 4. If each month's total gaming time is not being reduced, it could also indicate that the gamer is failing to cease gaming.

Question 5: Have you lost interest in previous hobbies and other entertainment activities as a result of your engagement with the game?

A possible way to examine the loss of interest in hobbies and other activities is by observing the amount of time spent over several months from different perspectives, on weekends or part of the day. If a gamer plays a lot during the day and at weekends, it could mean that s/he does not have time for hobbies.

To achieve this analysis, the therapist can examine if there exists a growth in the gaming time by day part (afternoon and evening) and by the weekday (midweek or weekend) presented in Figure 4. However, the therapist needs to know the patient's working or studying habits in order to interpret these indicators and visualizations correctly.

Question 8: Do you play in order to temporarily escape or relieve a negative mood (e.g., helplessness, guilt, anxiety)?

To accomplish the analysis of whether a patient uses gaming to escape from negative situations in their daily life, the therapist could observe the emotional status of the gamer before the session starts and analyze how negative (or positive) s/he feels. Then, compare with the end of the session, concluding the evolution of its feelings, through Figure 9-left. Hence, if positive emotions predominate at the beginning of the session, a possible hypothesis is to reject the relieving negative mood. Otherwise, there is a possibility that the motivation for gaming is to escape from negative thoughts. Furthermore, if the emotions get even worse over several consecutive matches, it can mean that gaming does not help to cope or escape the initial pessimistic scenario. Additionally, the therapist can analyze the emotional status at each match's beginning and end in Figure 9-right.

Question 9: Have you jeopardized or lost an important relationship, job or educational or career opportunity because of your gaming activity?

Similar to Q5, this question aims to determine if gaming impacts other activities, in this case, regarding educational and professional occupations rather than hobbies. We can argue that if gaming activity has increased or the intensity of the sessions is higher, it could be difficult for the patient to engage in any other activity, such as a job or educational courses. To achieve this, the therapist can understand the tendency to spend time gaming, particularly on weekends or midweeks, using the visualization of Figure 4-right. If the gamer significantly increased their gaming time during the last months, s/he probably would have jeopardized his educational or professional career. Another interesting perspective to analyze is the gaming time by part of the day. If the gamer usually plays during work time, it is also possible that s/he negatively affects his professional career. This situation can be analyzed through the Figure 4-left. Once again, to correctly analyze this information, it is important to know the personal schedules of the patient and when s/he usually spends time on those jobs or educational careers.

5 Conclusion

This paper introduced a new methodology for analyzing gaming behavior indicators, aiming to enhance the diagnosis and comprehension of IGD. Leveraging behavioral telemetry data and extracting emotional states, the proposed metrics and visualizations provide a nuanced understanding of gamer behavior and emotion regulation. We used data from four gamers as use cases to explain the metrics and visualizations and to demonstrate the application of our method. Our findings outline the potential insights that can be gained from a tool that gathers these telemetry data, emotion regulation data, and gaming patterns. A tool composed of these precise indicators can aid healthcare professionals in diagnosing IGD and monitoring the therapeutic process, potentially helping to resolve some of the problems and difficulties associated with traditional methods of IGD assessment. Additionally, the metrics and visualizations can also inform therapists about each gamer's problematic behavior and gaming habits, allowing for personalized treatment tailored to the individual and their needs.

It is important to acknowledge several limitations of the proposed approach. First, our results are based on telemetry data from Counter-Strike, which may not fully capture the broader gaming habits of patients with IGD, who often engage with a variety of game genres. Additionally, as this is exploratory research, it lacks comprehensive clinical validation. Lastly, the absence of facial recordings during gameplay limits our ability to analyze emotional data.

Future research endeavors will focus on extending the application of our methodology to facilitate more personalized interventions for individuals affected by problematic gaming behaviors and validation. Expanding data collection to encompass telemetry from various genres and types of video games is essential. Additionally, it is important to develop an interactive and user-friendly application that allows health professionals to designate a specific gamer and subsequently access and analyze the metrics and visualizations presented, allowing a comprehensive understanding of gaming behaviors. This will allow us to validate our method with healthcare professionals to assess the tool's usability and helpfulness in assisting professionals with tasks such as diagnosis and monitoring of IGD.

Additionally, to mitigate the problem of the absence of datasets involving video gamers, we plan to conduct a longitudinal experimental study with repeated game sessions over several months. This study will include gamers of different profiles (professionals and amateurs, healthy and those with problematic behaviors) to collect video facial data, physiological data, and other relevant information. These datasets will enable us to explore correlations between emotional states, gaming behaviors, self-reported data, and IGD criteria. The overarching aim is to provide clinicians with objective indicators for a more informed assessment of gamers. We also envision extending our method to explore the impact of player interactions by analyzing communication logs and social network structures within the game. This will help us assess the correlation between these interactions, individual gaming behaviors, and emotional states.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

This study did not involve a user study with participants/gamers. Instead, we used publicly available gaming data from a few players to illustrate metrics and visualizations, solely for educational and research purposes. No personal or identifiable information was collected since the data available on the platforms only referred to game data.

Author contributions

AA: Conceptualization, Methodology, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MF: Conceptualization, Methodology, Supervision, Visualization, Writing – review & editing. JC: Conceptualization, Methodology, Supervision, Writing – review & editing. BV: Data curation, Formal analysis, Validation, Visualization, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Corrigendum: Towards an automated approach for understanding problematic gaming

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Incorrect Author Name

In the published article, an author's name was incorrectly written as [Beltran Vasquez]. The correct spelling is [Beltrán Vázquez].

The authors apologize for this error and state that this does not change the scientific conclusions of the article in any way. The original article has been updated.

Missing Author Contributions

In the published article, the contributions of Beltrán Vázquez are: [BV: Data curation, Formal analysis, Validation, Visualization, Writing – review & editing], and the correct contribution of Beltrán Vázquez is below:

[BV: Data curation, Formal analysis, Validation, Visualization, Writing – original draft].

The authors apologize for this error and state that this does not change the scientific conclusions of the article in any way. The original article has been updated.

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