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FULL-LENGTH REPORT



The withdrawal-related affective, gaming urge, and anhedonia symptoms of internet gaming disorder during abstinence

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ABSTRACT

Aim: The study explores IGD withdrawal-related presentations, including autonomic reaction, affective symptoms, anhedonia, and gaming urge during abstinence from gaming. We prospectively evaluated these withdrawal-related symptoms (WRS) and gaming craving during abstinence from gaming. **Methods:** We examined 69 individuals with IGD and 69 regular gamers and evaluated their WRS (using an exploratory questionnaire), affective and behavioral WRS (using the Questionnaire on Gaming Urge-Brief Version gaming disorder questionnaire), and heart rate. All the participants attempted to abstain from gaming before our assessment. Subsequently, some participants' WRS and gaming craving before they engaged in gaming were prospectively evaluated. **Results:** In the IGD group, 85.5% experienced gaming WRS, including affective, anhedonia, and gaming urge symptoms. They could relieve these symptoms through gaming. The IGD group experienced more severe gaming WRS, gaming craving, and a higher heart rate than the regular gamer group. Gaming urge was most associated WRS of IGD. Participants with IGD experienced more severe gaming cravings when their gaming abstinence before the assessment was shorter. WRS attenuated at night and the following morning when they maintained their gaming abstinence after assessment. **Conclusion:** Individuals with IGD experience withdrawal-related affective, anhedonia, and gaming urge symptoms and a higher heart rate during abstinence. The WRS attenuated in 1 day. Most participants agreed that these symptoms could be relieved through gaming. Further prospective evaluation by objective assessment in an adequate sample was required to understand gaming withdrawal symptoms comprehensively.

KEYWORDS

internet gaming disorder (IGD), gaming withdrawal, affective, anhedonia, gaming urge, gaming craving

INTRODUCTION

Online gaming is a popular recreational activity worldwide (WePC, 2019). Although gaming benefits skill training and educational development (Cade & Gates, 2017), many people cannot control their gaming habits, resulting in negative consequences. The loss of control in gaming is defined as internet gaming disorder (IGD) in the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-5); this definition was established in 2003 (American

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Psychiatric Association [APA], 2013). However, scholars are concerned about addictive characteristics in gaming behavior (Dowling, 2014; Kardefelt-Winther, 2014; Starcevic, 2017). Withdrawal symptoms are included in the DSM-5 criteria (APA, 2013) and other essential assessment instruments such as the IGD-20 (King, Haagsma, Delfabbro, Gradisar, & Griffiths, 2013; Pontes, Kiraly, Demetrovics, & Griffiths, 2014). Because gaming does not have a pharmacological effect, the presence of withdrawal symptoms in individuals with IGD is a topic of concern that warrants further investigation.

WITHDRAWAL SYMPTOMS OF IGD

DSM-5 states that the withdrawal symptoms that occur when an individual is forced to stop internet gaming include irritability, anxiety, or sadness (APA, 2013). Griffith et al. (2010) referred to withdrawal symptoms as the unpleasant feeling states and/or physical effects when online gaming is discontinued or suddenly reduced. Kaptis, King, Delfabbro, and Gradisar (2016a) assessed gaming withdrawal using a questionnaire to evaluate craving levels before and after abstinence from gaming; they discovered that the craving response decreased over time during abstinence from gaming. Kaptis et al. (2016a) also reviewed related studies that examined withdrawal and IGD (Kaptis et al., 2016a). Most studies have reported withdrawal symptoms such as anxiety, moodiness, sadness, and irritability following abstinence, which correspond to the symptoms stated in DSM-5. Several researchers have referred to withdrawal symptoms as a desire or craving to play video games (Han, Hwang, & Renshaw, 2010; Kaptis et al., 2016a) and have highlighted that the empirical evidence of the withdrawal symptoms of IGD is inconclusive.

Withdrawal symptoms have clinical implications. King et al. (2013) reviewed instruments used to assess IGD and suggested that IGD is commonly defined by withdrawal, loss of control, and conflict. Withdrawal symptoms are also valid criteria for differentiating individuals with IGD from healthy controls (Ko et al., 2014). Ko et al. (2014) argued that people with IGD cannot refrain from gaming for more than 2 or 3 days; however, the duration of gaming abstinence required to provoke irritability is challenging to determine. Thus, the physical and psychological presentation after abstinence from gaming should be evaluated to clarify the nature of withdrawal symptoms.

A high heterogeneity characterizes substance use disorder in the course and presentation of withdrawal symptoms (Piper, 2015). Piper (2015) investigated nicotine withdrawal symptoms and suggested that the timings of negative affective and craving symptoms differ between individuals. They suggested that other than the internal cue of decreasing drug levels, environmental cues and the absence of drug self-administration influence the development of withdrawal symptoms (Piper, 2015). Thus, biological, personal, environmental, and behavioral factors can contribute to withdrawal symptoms. Furthermore, a study demonstrated that

withdrawal causes both rats and humans to exhibit reduced responses to rewards (Pergadia et al., 2014). Piper (2015) suggested that the attenuation of the ability to experience pleasure is a withdrawal symptom. The aforementioned reviews indicate that gaming withdrawal symptoms should be evaluated by considering multiple dimensions of presentation and the course of withdrawal.

Thus, this study 1) assessed the presentations of WRS (including autonomic reaction, negative emotion, anhedonia, and gaming urge), 2) prospectively evaluated the presentations of WRS during gaming abstinence, and 3) investigated the association between gaming craving and WRS.

METHODS

Participants

In this case-control study, adults aged 20–38 years with IGD (IGD group) and matched regular gamers (RGs; RG group) were enrolled by posting advertisements on university internet bulletin boards. To examine the WRS during gaming abstinence, we enrolled RGs frequency-matched by gender and age (± 3 years) and assigned them to the control group (i.e., RG group). Individuals who engaged in regular online gaming (≥ 3 days per week) but did not meet the diagnostic criteria for IGD were enrolled as RGs. The diagnoses of IGD for both groups were confirmed through psychiatric interviews based on DSM-5 criteria. Psychotic disorders, bipolar I disorder, and substance use disorder was excluded (MINI; Sheehan et al., 1998).

Measures

DSM-5 Diagnostic Criteria for IGD. We conducted a semi-structured interview to examine the severity and frequency of each DSM-5 criterion in the IGD group. Participants who met five or more criteria were assigned to the IGD group (APA, 2013).

Exploratory Questionnaire for Withdrawal Symptoms (EQfWS). We evaluated the behavioral presentation and three dimensions of WRS of IGD by administering a yes/no questionnaire for previous withdrawal experiences. We asked the participants whether they experienced specific WRS when they had stopped or were forced to stop gaming for a period in the past year. The first dimension was affective reactions, which included feelings of depression, anxiety, irritability, and frustration per the DSM-5 criteria for IGD (APA, 2013). The secondary dimension was anhedonia symptoms, which included boredom, inability to experience pleasure, disinclination for activity, and inability to identify activities to do per a previous review of withdrawal symptoms (Piper, 2015). The third dimension was gaming urge, which included preoccupation, urges to gaming, and attempts to find games to play. We also asked the participants to explain why they must play games after stopping them for a period of time; the cited reasons

included emotional distress (irritability or dysphoria), lack of satisfaction, gaming urge, a need to fulfill one's mission, boredom or idleness, and execution of a daily ritual. The results are presented in Table 2.

Affective and Behavior Withdrawal Symptoms of Gaming Disorder Questionnaire (Appendix 1). To objectively evaluate the current WRS of IGD, we developed the Affective and Behavior Withdrawal Symptoms of Gaming Disorder Questionnaire (**ABWSGDQ**), a 15-item questionnaire that corresponded to the DSM-5 criteria, protocols of previous studies, and our clinical experience. The symptoms include affective presentations, anhedonia symptoms, and gaming urge in the appendix. All items were significantly different between IGD and RG groups in independent *t*-tests. Furthermore, all items were significantly correlated with the total score of the **ABWSGDQ**; therefore, the items were all included in the questionnaire. We used the 15 items to represent the withdrawal symptoms of IGD, with a higher score indicating a more severe withdrawal symptom. Cronbach's alpha was 0.96. The test-retest reliability of 58 participants was 0.87 ($P < 0.001$). The score for the **ABWSGDQ** was significantly correlated with the results for the Chen Internet Addiction Scale-Gaming Version (**CIAS-G**; 0.35, $P = 0.003$) and the score for gaming urge (0.27, $P = 0.03$).

Questionnaire on Gaming Urge, Brief Version (Ko et al., 2013). The Questionnaire on Gaming Urge, Brief Version (**QGU-B**) is a modification of the Questionnaire on Smoking Craving, Brief Version (**QSU-B**) used by Cox, Tiffany, and Christen (2001). The intensity of the 10-item **QGU-B** is represented by a score from 1 to 7. A higher score indicates higher gaming craving. The total **QGU-B** score was significantly correlated with the Chen Internet Addiction Scale-Gaming Version (**CIAS-G**) score. The scale's internal reliability γ was 0.99, and its test-retest reliability was 0.96.

Chen Internet Addiction Scale-Gaming Version. The **CIAS-G** is a 4-point, 26-item self-reported scale that was used to assess the five dimensions of Internet addiction, namely compulsive use, withdrawal, tolerance, problems with interpersonal relationships, and problems with health and time management (Chen, 2003). The colloquial phrasing used in the original **CIAS** was modified to assess participants' online gaming experiences. Our modified version (i.e., **CIAS-G**) had a Cronbach's alpha of 0.96 (Ko, Yen, Chen, Chen, & Yen, 2005). The total **CIAS-G** score ranged from 26 to 104, with a higher score indicating more severe IGD.

Heart rate variability. The heart rate variability (HRV) assessment was performed when participants were asked to maintain a relaxed state and breathe freely in a seated. An 8-bit analog-to-digital converter with a sampling rate of 512 Hz was used for signal recording (SS1C, Enjoy Research Inc., Taiwan). Two thousand forty-eight data points covering 288 s were produced through interpolation and used in the subsequent fast Fourier transform. High-frequency (HF; between 0.15 and 0.4 Hz) power indicated parasympathetic activity, whereas low-frequency (LF;

between 0.04 and 0.15 Hz) one indicated modulation through sympathetic and parasympathetic activity. The LF/HF ratio reflected the balance of sympathetic and parasympathetic activity (Kuo et al., 1999). The standard deviation of normal-to-normal RR intervals (SDNN, which is a time-domain index) reflected the overall variability relating to the coverage of LF and HF.

Psychiatric comorbidity

The psychiatric comorbidity, including attention-deficit/hyperactivity disorder (ADHD), depressive disorder, generalized anxiety disorder, and social anxiety disorder, were also evaluated based on MINI (Sheehan et al., 1998) and DSM-5 (APA, 2013). The psychiatric comorbidity and the comorbidity rate were detailed in a previous report (Ko et al., 2021).

Procedure (Fig. 1)

Both IGD group and regular gamers were asked to abstain from gaming before visiting the assessment laboratory. It makes them respond to the questionnaire for current withdrawal symptoms in **ABWSGDQ**. They completed the diagnostic interview and assessment mentioned above on the morning of Day 1. The **EQfWS** assesses previous withdrawal symptoms, and the **ABWSGDQ** assesses the severity of current withdrawal symptoms. Subsequently, 30 participants from the IGD group consented to abstain from gaming until they could not keep abstinence after leaving the lab to assess withdrawal symptoms prospectively. We tracked their gaming from the night of Day 1 (first follow-up) to the morning of Day 2 (second follow-up) and their scoring in **ABWSGDQ** and **QGU-B** based on email assessment. They were also requested to complete and send back the **ABWSGDQ** and **QGU-B** before and after gaming when they first re-engaged after leaving the lab.

Statistical analysis

The chi-square analysis was performed to evaluate the association of withdrawal symptoms (identified in the exploratory questionnaire) with IGD. Independent *t*-tests were conducted to evaluate the age differences; scores for the **ABWSGDQ**, **QGU-B**, and **CIAS-G**; and HRV results between the IGD and RG groups. The linear logistic regression evaluated the association between the score of **ABWSGDQ** or **QGU-B** and IGD in control of confounding factors, such as abstinence duration or psychiatric comorbidity. Pearson's analysis was conducted to evaluate the correlation between the scores for the **ABWSGDQ**, **QGU-B**, and **CIAS-G** and HRV within the IGD group. The IGD group was further segmented into the short (0–6 h) and long (6–24 h) withdrawal groups. We performed *t*-tests to evaluate the differences between the short and long withdrawal groups regarding their scores for the **ABWSGDQ**, **QGU-B**, **CIAS-G**, and HRV among the IGD group. Finally, the paired *t*-test was used to evaluate the differences in **ABWSGDQ** and **QGU-B** scores between the first evaluation and first follow-up, between the first and second follow-up, between the first

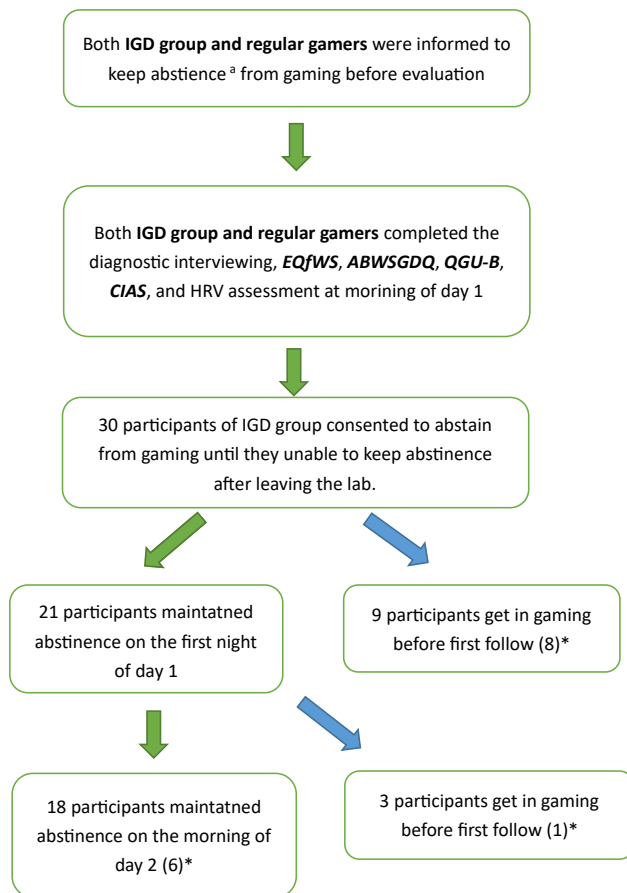


Fig. 1. The study process

^a The duration of abstinence before assessment was show in Table 1.

* Participants had completed the Affective and Behavior Withdrawal Symptoms of Gaming Disorder Questionnaire and Questionnaire on Gaming Urge, Brief Version, by using E mail, before gaming and after gaming when they re-engaging gaming.

evaluation and pre-gaming period, and between the pre- and post-gaming periods. A P -value of <0.05 was considered statistically significant for all analyses, which were performed using SPSS (version 26).

Ethics

We enrolled at a total of 69 participants in the IGD group and 69 in the RG group after obtaining their informed consent. The study was approved by the Institutional Review Board of Kaohsiung Medical University Hospital, Taiwan (KMUHIRB-SV(II) -20150081).

RESULTS

No difference in gender and age was observed between the IGD and RG groups (Table 1).

WRS of IGD and RG groups

The chi-square analysis presented in Table 1 indicated that individuals with IGD were more likely to experience difficulties

Table 1. Chi-Square analysis of gender and withdrawal-related symptoms of internet gaming disorder (IGD) and regular gamer groups

	Regular gamer ($N = 69$) ($N\%$)	Participants with IGD ($N = 69$) ($N\%$)	X^2
Gender			
Male	54 (78.3%)	54 (78.3%)	0.000
Female	15 (21.7%)	15 (21.7%)	
Duration of gaming abstinence before assessment			
0–6 h	26 (37.7%)	47 (68.1%)	19.57***
6–24 h	31 (44.9%)	22 (31.9%)	
2–3 days	12 (17.4%)	0 (0.0%)	
Behavioral presentation			
Did you have difficulties maintaining gaming abstinence for 3 days?			
Yes	18 (26.1%)	61 (88.4%)	54.74***
No	51 (73.9%)	8 (11.6%)	
Have you engaged in near continual gaming for 3 days?			
Yes	35 (50.7%)	54 (78.3%)	11.42**
No	34 (49.3%)	15 (21.7%)	
Did you experience emotional distress after abstaining from gaming?			
I did not abstain from gaming for a period of time	11 (15.9%)	10 (14.5%)	26.76***
No, not even after I abstained from gaming	37 (53.6%)	10 (14.5%)	
Yes	21 (30.4%)	49 (71.0%)	

** $P < 0.01$; *** $P < 0.001$.

in maintaining abstinence from gaming for 3 days ($X^2 = 54.74$; $P < 0.001$), continue gaming for 3 days ($X^2 = 11.42$; $P = 0.001$), and experience emotional distress after abstaining from gaming ($X^2 = 26.76$; $P < 0.001$). In the IGD group, 14.5% did not experience any discomfort after abstaining from gaming. Subsequently, 58 individuals with IGD (one participant was missing) participated in further assessments; the results are presented in Table 2.

Further assessments of participants with IGD revealed that 23.1%, 42.0%, 62.3%, and 7.3% of them experienced the WRS of dysphoria, anxiety, irritability, and frustration, respectively. In total, 54 participants (78.3%) in IGD group experienced affective symptoms; 16(23.2%), 22(31.9%), and 9 (13.0%) experienced affective symptoms one day, two days, and >3 days, respectively, after commencing gaming abstinence; 49 (71%) ones indicated that they could relieve these symptoms through gaming. On the other hand, 19 regular gamers (27.5%) experienced withdrawal-related affective symptoms.

Among IGD group, 43(62.3%), 14(20.3%), 28(40.6%), and 36 (52.2%) participants reported experiencing the WRS of boredom, inability to experience pleasure, disinclination toward activity, and inability to find things to do. In total, 56 (81.2%) participants of IGD experienced withdrawal-related anhedonia symptoms; 25(36.2%), 18(26.1%), and 7 (10.1%)

Table 2. Self-reported withdrawal-related affective, anhedonia, and gaming urge symptoms among individuals with internet gaming disorder (IGD) and regular gamers

	IGD(%)	Regular gamer (%)
Withdrawal-related affective symptoms		
Dysphoria	16 (23.1%)	2 (2.9%)
Anxiety	29 (42.0%)	7 (10.1%)
Irritability	43 (62.3%)	17 (24.6%)
Frustration	5 (7.3%)	2 (2.9%)
Relief through gaming	49 (71%)	16 (23.2%)
Symptom onset after abstaining from gaming	N = 54 (78.3%)	N=19 (27.5%)
0.5–1 day	16 (23.2%)	4 (5.8%)
1–2 days	22 (31.9%)	8 (11.6%)
>3 days	9 (13.0%)	4 (5.8%)
No consistent timing	7 (10.1%)	3 (4.3%)
Withdrawal-related anhedonia syndrome		
Boredom	43 (62.3%)	16 (23.2%)
Inability to experience pleasure	14 (20.3%)	6 (8.7%)
Disinclination for activity	28 (40.6%)	4 (5.8%)
Inability to find things to do	36 (52.2%)	14 (20.3%)
Relief through gaming	53 (76.8%)	20 (29.0%)
Symptom onset after abstaining from gaming	N = 56 (81.2%)	N=22 (31.9%)
0.5–1 day	25 (36.2%)	8 (11.6%)
1–2 days	18 (26.1%)	7 (10.1%)
>3 days	7 (10.1%)	4 (5.8%)
No consistent timing	6 (8.7%)	3 (4.3%)
Withdrawal-related gaming urge		
Preoccupation	47 (68.1%)	13 (18.8%)
Urge to game	33 (47.8%)	7 (10.1%)
Attempts to find games to play	23 (33.3%)	4 (5.8%)
Relief through gaming	51 (73.9%)	16 (23.2%)
Symptom onset after abstaining from gaming	N = 55 (79.7%)	N=16 (23.2%)
0.5–1 day	28 (40.6%)	6 (8.7%)
1–2 days	18 (26.1%)	7 (10.1%)
>3 days	5 (7.3%)	1 (1.4%)
No consistent timing	5 (7.3%)	2 (2.9%)
Reasons for playing games		
Irritability or dysphoria	35 (50.7%)	13 (18.8%)
Unsatisfied needs for happiness	28 (40.6%)	13 (18.8%)
Urge to game	37 (53.6%)	7 (10.1%)
Unresolved gaming missions	37 (53.6%)	12 (17.4%)
Boredom or lack of activities to do	44 (63.8%)	15 (21.7%)
Status of gaming as a daily ritual	39 (56.5%)	15 (21.7%)
Most crucial reason		
Status of gaming as a daily ritual activity	20 (29.0%)	8 (11.6%)
Boredom or lack of activities to do	12 (17.4%)	5 (7.2%)
Unresolved gaming missions	10 (14.4%)	3 (4.3%)
Irritability or dysphoria	7 (10.1%)	2 (2.9%)
Urge to game	5 (7.3%)	1 (1.4%)
Unsatisfied needs for happiness	4 (5.8%)	3 (4.3%)

%; Percentage among 69 participants with IGD or 69 controls.

experienced anhedonia symptoms one day, two days, and >3 days, respectively, after commencing gaming abstinence; 53 (76.8%) ones indicated that they could relieve these

symptoms through gaming. On the other hand, 22 regular gamers (31.9%) experience anhedonia symptoms.

The evaluation of withdrawal-related gaming urge revealed that 47(68.1%), 33(47.8%), and 23 (33.3%) participants of IGD reported experiencing preoccupation, urges to gaming, and attempts to find games to play, respectively. In total, 55 participants (79.7%) experienced gaming urge; 28(40.6%), 18(26.1%), and 5 (7.3%) with IGD experienced gaming urge-related symptoms one day, two days, and >3 days, respectively, after commencing gaming abstinence; 51 (73.9%) ones indicated that they could relieve these symptoms through gaming. On the other hand, 16 regular gamers (23.2%) experience gaming urge.

The 58 participants of IGD indicated that they had to play games because of irritability or dysphoria (35; 50.7%), unsatisfied needs for happiness (28; 40.6%), urges to game (37; 53.6%), unresolved gaming missions (37; 53.6%), boredom or lack of activities to do (44; 63.8%), and status of gaming as a daily ritual (39; 56.5%); 20(29.0%), 12(17.4%), and 10 (14.4%) of the participants indicated that the status of gaming as a daily ritual, boredom or lack of activities to do, and unresolved gaming missions were the most essential factors that contributed to their re-engaging gaming.

WRS and gaming urge of IGD and RG groups

The independent-*t* test (Table 3) revealed that relative to the RGs, the participants with IGD exhibited more pronounced WRS ($t = 7.51, P < 0.001$), stronger gaming craving ($t = 11.78, P < 0.001$), greater IGD severity ($t = 12.42, P < 0.001$), and higher heart rates ($t = 2.20, P = 0.03$). The difference in WRS ($t = 4.65, P < 0.001$; $t = 5.66, P < 0.001$) and gaming craving ($t = 7.32, P < 0.001$; $t = 10.47, P < 0.001$) were all significant with control of abstinence duration or psychiatric comorbidity in linear regression analysis show in [supplement table 1](#). In these regressions, lower abstinence duration associated with higher gaming craving and comorbidity with ADHD associated with higher WRS.

Compared with RGs, the participants with IGD also exhibited more pronounced WRS with respect to the affective ($t = 5.78, P < 0.001$), anhedonia ($t = 6.28, P < 0.001$), and gaming urge ($t = 9.95, P < 0.001$) dimensions. A regression of the IGD results with respect to the three dimensions of withdrawal symptoms revealed that gaming urge significantly predicted IGD (OR = 2.06, 95% confidence intervals = 1.53–2.77). Anhedonia and affective symptoms predicted insignificantly in control of gaming urge, suggesting that gaming urge is the most associated dimension of IGD. The correlation analysis presented in Table 4 indicated that the severity of IGD correlated with withdrawal symptoms ($r = 0.35, P = 0.003$) and gaming craving ($r = 0.39, P = 0.001$) in the IGD group. WRS were also correlated with gaming craving ($r = 0.27, P = 0.03$) in marginal significance.

Association of duration of gaming abstinence with WRS and gaming urge

An independent *t*-test revealed that participants who abstained from gaming for 6–24 h before assessment

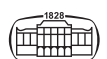


Table 3. Age, Withdrawal-Related Symptoms (WRS), gaming urge, severity of IGD, and heart rate variability among individuals with internet gaming disorder (IGD) and controls with regular gaming habit

	IGD	Regular gaming	<i>t</i> test
	(<i>N</i> = 69) <i>N</i> (%)	(<i>N</i> = 69) <i>N</i> (%)	
	Mean ± SD	Mean ± SD	
Age	25.32 ± 4.20	24.59 ± 3.41	1.11
WRS ^a	39.97 ± 12.04	26.46 ± 8.86	7.506***
Affective (8 items) ^a	19.87 ± 6.93	13.91 ± 5.03	5.78***
Anhedonia (4 items) ^a	11.33 ± 4.21	7.48 ± 2.89	6.28***
Gaming urge (3 items) ^a	8.77 ± 2.32	5.07 ± 2.03	9.95***
Gaming craving ^b	52.61 ± 7.60	32.70 ± 11.80	11.783***
Severity of IGD ^c	82.87 ± 10.49	55.87 ± 14.69	12.423***
Heart rate ^d	79.49 ± 11.29	75.07 ± 12.30	2.195*
SDNN ^d	62.89 ± 45.33	61.11 ± 40.27	0.242
HF ^d	5.97 ± 1.43	6.11 ± 1.41	-0.595
LF percent ^d	59.27 ± 17.30	59.25 ± 17.35	0.006
VL ^d	6.70 ± 1.44	6.70 ± 1.35	0.024
LF ^d	6.67 ± 1.18	6.76 ± 1.31	-0.445
HF percent ^d	31.20 ± 14.22	32.30 ± 14.40	-0.451
LF/HF ^d	0.69 ± 0.87	0.64 ± 0.75	0.357

^a Total and subscale scores for Affective and Behavior Withdrawal Symptoms of Gaming Disorder Questionnaire.

^b Questionnaire on Gaming Urge-Brief Version.

^c Chen Internet Addiction Scale-Gaming Version.

^d Frequency-domain category of heart rate variability: SDNN, standard deviation of normal-to-normal RR intervals; HF, parasympathetic activity; LF is modulated by sympathetic and parasympathetic activity; LF/HF, balance of sympathetic and parasympathetic activity.

P* < 0.05; **P* < 0.001.

Table 4. Correlation between Withdrawal-Related Symptoms (WRS), gaming urge, heart rate, and severity of internet gaming disorder (IGD) among individuals with IGD

Variables	WRS ^a	Gaming craving ^b	HR	Severity of IGD
IGD group				
Affective symptoms ^a		0.21	0.04	0.26*
Anhedonia ^a		0.18	-0.02	0.36**
Gaming urge ^a		0.44***	0.08	0.41***
Gaming craving ^b	0.27*			
HR	0.032	-0.054		
Severity of IGD ^c	0.35**	0.39**	-0.087	

^a Total and subscale scores for Affective and Behavior Withdrawal Symptoms of Gaming Disorder Questionnaire.

^b Questionnaire on Gaming Urge-Brief Version.

^c Chen Internet Addiction Scale-Gaming Version.

P* < 0.05; *P* < 0.01; ****P* < 0.001.

exhibited a lower score for gaming craving (49.05 ± 7.63) relative to those who abstained from gaming for 0–6 h (54.28

± 7.06; *t* = 2.80, *P* = 0.007). However, no difference in WRS was observed. The same results were noted among regular gamers (supplement table 2). The linear regression demonstrated that significant group effect and abstinence duration effect on the gaming craving without significant interaction (supplement table 1).

Within-group comparison of WRS and gaming craving through prospective investigation

In total, 21 participants with IGD maintained abstinence from gaming as shown in Table 6. They completed the first follow-up investigation on the first night, at which point they experienced significantly less severe withdrawal symptoms (33.86 ± 11.23) relative to the time of the first evaluation (42.72 ± 10.04; *t* = 4.47, *P* < 0.001). A total of 18 participants with IGD continued to abstain from gaming the following morning. No difference in WRS was observed between the first (34.56 ± 11.42) and second follow-up assessments (32.94 ± 10.31). A total of 15 individuals completed the assessment before and after they started gaming; although the score in WRS and gaming craving was higher during the pre-gaming period (34.20 ± 12.83; 52.00 ± 14.10) relative to the post-gaming period (28.07 ± 11.20; 42.60 ± 14.61), but not reach significant difference.

DISCUSSION

Three dimensions of WRS in IGD

In the present study, 85.5% of the participants in the IGD group indicated that they could not abstain from gaming for more than one day or experience withdrawal symptoms. Most of the participants with IGD experienced withdrawal-related affective symptoms (78.3%), anhedonia (81.2%), and gaming urge (79.7%), and they also reported that most of these symptoms could be relieved through gaming. These findings suggest that WRS of IGD include affective, anhedonia, and gaming urge symptoms. Several studies have demonstrated that withdrawal symptoms are a core presentation in the diagnosis and assessment of IGD (King et al., 2013; Pontes et al., 2014). However, Wichstrom, Stenseng, Belsky, von Soes, and Hygen (2019) reported a poor association between withdrawal and IGD diagnosis. The multiple dimensions of WRS could have contributed to the inconsistent results of previous studies. The exploratory data support the presence of the three dimensions of WRS.

Withdrawal-related gaming urge symptoms

Gaming urge symptoms include preoccupation, urge to game, and attempts to find a game to play. These symptoms are similar to the craving symptoms reported by Kaptis et al. (2016a), and identical to the craving responses of addictive disorder. This finding suggests that craving is a dimension of WRS, which is the case for nicotine withdrawal (Piper, 2015). Drug withdrawal may trigger an internal cue

that leads to a craving response (Tiffany, 1990). The high correlation between withdrawal-related gaming urge and gaming craving in this study suggested it is challenging to distinguish them in clinical presentation. Furthermore, gaming urge is the WRS that is most associated with IGD. Thus, gaming urge may be the most crucial WRS to be assessed among individuals with IGD.

Previous studies have demonstrated that most individuals with IGD experience withdrawal symptoms within three days after gaming abstinence. The present study indicated that withdrawal-related gaming urge symptoms mainly occurred between 0.5 and 1 day after abstinence. Because gaming does not have any pharmacological effects, abstinence may trigger gaming urge through the behavior withdrawal model, which was proposed for nicotine withdrawal (Piper, Cook, Schlam, Jorenby, & Baker, 2011). The breaking of behavioral rituals can trigger withdrawal symptoms because ritual gaming behaviors condition an individual to experience pleasure from gaming. In the present study, gaming status as a daily ritual was the most frequently cited key reason the participants with IGD re-engaged in gaming. This finding partially supports the model of behavior withdrawal, which requires further verification through future studies.

Withdrawal-related anhedonia symptoms

Anhedonia symptoms include boredom (the most frequently reported symptom), inability to experience pleasure, disinclination for activity, and inability to find things to do. Piper (2015) and Cook et al. (2015) have suggested the anhedonia symptom, inability to experience pleasure, is a component of withdrawal symptoms. Under nicotine dependence, neuroadaptations (desensitization) in the reward system may lead to a reduction in reward responsiveness during abstinence (Miyata & Yanagita, 2001; Piper et al., 2011). A study demonstrated that online gamers who gamed frequently exhibited a lower reward response (Hahn et al., 2014). In the present study, the participants experience anhedonia 0.5–1 day after commencing abstinence and relieve it through gaming. Thus, anhedonia may play a role in relapse risk, which is the case for tobacco use disorder (Cook et al., 2015).

Withdrawal-related affective symptoms

The withdrawal-related affective symptoms in the present study correspond to the DSM-5 criteria (i.e., depression, anxiety, and irritability). Irritability was the most frequently reported affective symptom in the present study. This finding supports the claim by Kaptsis, King, Delfabbro, and Gradisar (2016b) that irritability following the cessation of gaming is the gaming withdrawal symptom that occurs most consistently. A study (Yen, Yeh, et al., 2017) highlighted a higher level of irritability among individuals with IGD, which could contribute to their irritability during gaming abstinence. Furthermore, these symptoms mostly appeared between 1 and 2 days after commencing abstinence. The onset of affective symptoms occurred later than those related to anhedonia and gaming urge. This finding suggests that

persistent anhedonia that manifest as an inability to experience pleasure may trigger the onset of affective symptoms such as irritability and depression. However, further investigation is required to verify this claim.

Withdrawal-related autonomic function alteration

The present study revealed that participants with IGD exhibited a higher heart rate during abstinence relative to the RGs. However, the HRV results did not reveal any difference in autonomic function. A study that examined acute alcohol withdrawal symptoms also reported a higher heart rate without any difference in HRV (Bär et al., 2006). Our results partly support that individuals with IGD experience physiological WRS during abstinence. However, this marginally significant difference was observed in a limited size sample. Furthermore, a high heart rate is associated with craving responses (Kennedy et al., 2015). Thus, the role of a high heart rate in gaming withdrawal requires further clarification to determine its clinical significance.

The course of gaming WRS

Relative to the RGs, the participants in the IGD group exhibited more severe WRS and gaming urge (Tables 1 and 3). The self-reported data indicated that the gaming urge and anhedonia mainly occurred 0.5–1 day after abstinence, whereas affective symptoms mainly occurred 1–2 days after that. These results may explain why 78.3% of the participants with IGD did not abstain from gaming for >3 days. They also suggest that individuals with IGD exhibit more severe WRS and are less likely to abstain from gaming. Furthermore, the prospective data of 21 participants with IGD indicated a reduction in their WRS during the night of Day 1. This finding corresponds to the results reported by Kaptsis et al. (2016a), that is, withdrawal symptoms attenuated rapidly. This result suggests that WRS are intense only for a short duration. However, clinical case examples indicate that individuals with IGD re-engaged in gaming activities even after several days of gaming abstinence. On the other hand, this result could occur in a fluctuated withdrawal course which was determined by environmental factors such as gaming cues, stress, sleep, or others. A further prospective design was necessary to clarify these two assumptions.

Most of the participants with IGD agreed that their WRS could be relieved through gaming. Our prospective evaluation revealed that the WRS score of the participants with IGD decreased from 34.20 to 28.07 after they re-engaged in gaming following abstinence. However, no significant difference was observed because of the limited sample size ($N = 15$). Future investigations involving adequate sample sizes are required to verify the relief of withdrawal symptoms through gaming.

The comorbid psychiatric disorder and WRS

The linear regression analysis demonstrated that comorbid adult ADHD is associated with higher WRS. Under

abstinence, smokers with ADHD experience greater difficulty concentrating and impatience/restlessness than those without ADHD (Bidwell, Balestrieri, Colby, Knopik, & Tidey, 2018). In line with this previous study, we could not conclude whether these higher WRS were exacerbated by abstinence from gaming or were elevated by pre-existing ADHD symptoms. Nevertheless, the higher WRS might contribute to stronger negative reinforcement for gaming behavior. Thus, the gaming WRS among individuals with IGD and ADHD should be further evaluated in a future study to be effectively intervened.

The course of gaming craving

The participants with IGD who abstained for a shorter duration exhibited a more severe gaming craving than those who abstained for a longer duration (Table 5). Kaptis et al. reported that gaming urge decreased rapidly on the first day (Kaptis et al., 2016a). Thus, those who maintain a longer duration of abstinence experience a decrease in their gaming craving over time. Conversely, our within-group analysis indicated that the participants with more severe IGD exhibited a more severe gaming craving, suggesting that participants with IGD and a more severe gaming craving could not maintain a long duration of abstinence before the study. Thus, an environmental or activity intervention (e.g., a camp) study which may satisfy the reward system or block the behavioral rituals of individuals with IGD was necessary to help them endure their withdrawal symptoms and gaming craving to control their gaming.

Table 5. Difference in Withdrawal-Related Symptoms(WRS), gaming urge, severity of IGD, and heart rate variability between short and long withdrawal groups among IGD group

	0-6 h (N = 47)	6-24 h (N = 22)	t test
	Mean ± SD	Mean ± SD	
WRS ^a	39.98 ± 11.22	39.95 ± 13.91	0.008
Gaming craving ^b	54.28 ± 7.06	49.05 ± 7.63	2.795**
Severity of IGD ^c	83.83 ± 10.55	80.81 ± 10.30	1.113
HR ^d	78.07 ± 10.77	82.68 ± 12.02	-1.573
SDNN ^d	66.01 ± 45.08	55.90 ± 46.20	0.848
HF ^d	6.03 ± 1.50	5.82 ± 1.26	0.558
LF percent ^d	57.99 ± 16.97	62.15 ± 18.10	-0.917
VL ^d	6.80 ± 1.58	6.49 ± 1.09	0.929
LF ^d	6.67 ± 1.22	6.66 ± 1.08	0.035
HF percent ^d	31.66 ± 13.51	30.19 ± 15.98	0.391
LF/HF ^d	0.63 ± 0.85	0.83 ± 0.94	-0.861

^a Score for Affective and Behavior Withdrawal Symptoms of Gaming Disorder Questionnaire.

^b Questionnaire on Gaming Urge-Brief Version.

^c Chen Internet Addiction Scale-Gaming Version.

^d Frequency-domain category of heart rate variability: SDNN, the standard deviation of normal-to-normal RR intervals; HF, parasympathetic activity; LF is modulated by sympathetic and parasympathetic activity; LF/HF, the balance of sympathetic and parasympathetic activity.

**P < 0.01.

Table 6. Within-group comparison of Withdrawal-Related Symptom(WRS) and gaming craving results obtained during initial evaluation, first evaluation (first night), second evaluation (next morning), and third evaluation (next night)

	WRS ^a		Gaming craving ^b	
	Mean ± SD	Paired t test	Mean ± SD	Paired t test
N = 21				
First evaluation	42.72 ± 10.04	4.471***	52.71 ± 7.91	1.731
First follow-up at night	33.86 ± 11.23		47.14 ± 14.28	
N = 18				
First follow-up	34.56 ± 11.42	1.110	47.67 ± 14.42	-0.709
Second follow-up on next morning	32.94 ± 10.31		50.77 ± 13.54	
N = 15				
First evaluation	40.20 ± 11.31	1.699	54.53 ± 6.37	0.636
Before gaming	34.20 ± 12.83		52.00 ± 14.10	
N = 15				
Before gaming	34.20 ± 12.83	1.854	52.00 ± 14.10	1.601
After gaming	28.07 ± 11.20		42.60 ± 14.61	

^a Score for Affective and Behavior Withdrawal Symptoms of Gaming Disorder Questionnaire.

^b Questionnaire on Gaming Urge-Brief Version.

***P < 0.001.

Limitations

The interpretation of our exploratory investigation results is subject to several limitations. First, the sample size of our prospective investigation was small, limiting the study's power. Second, the gaming behavior and abstinence data were self-reported and not based on objective evidence. Third, participants of the IGD group reported their abstinence after lab evaluation by email. The recall bias and incompliance in the report could not be absolutely prevented.

Further, only the IGD group participate the prospective evaluation after the first evaluation. There is no comparison group in prospective evaluation of withdrawal symptoms. Thus, we could not conclude whether there is a difference in the course of WRS between the IGD group and regular gamers. Fourth, without a mechanism study, the presenting study indicates that the WRS showed in a withdrawal situation but was not caused by withdrawal from gaming. Fifth, although we evaluated the association between comorbidity and withdrawal symptoms in supplement data, the detailed analysis of comorbidity was not adequately assessed in this study. Lastly, we did not correct all results for the multiple comparison correction in this



exploratory study, and type 1 error could not be prevented. However, most results in this study are robust to survival in multiple comparison corrections, such as Holm–Bonferroni method.

CONCLUSION

This study verifies that most individuals with IGD experience withdrawal-related affective, anhedonia, and gaming urge symptoms and higher heart rates when they abstain from gaming. Individuals with more severe IGD exhibited more severe WRS and gaming craving. They reported that the onset of these symptoms mainly occurred 1–2 days after abstinence and that these symptoms could be relieved through gaming. Individuals with IGD had higher WRS and gaming craving than regular gamers without IGD. The prospective evaluation supports that the WRS declined in one day. Further study with an adequate sample to prospectively investigate the course of withdrawal symptoms with objective evaluation was necessary to prove the mechanism of gaming withdrawal symptoms.

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Authors’ contribution: Ju-Yu Yen interpreted the data and drafted the manuscript. Chih-Hung Ko and Pai-Cheng Lin acquired. Hung-Chi Wu and Chih-Hung Ko analyzed the data. Chih-Hung Ko designed this study and provided final approval for the published version.

Conflict of interest: The authors declare that they have no conflicts of interest.

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APPENDIX 1

Affective and Behavioral Withdrawal Symptoms of Gaming Disorder Questionnaire (ABWSGDQ)

Please respond to each item below regarding how you currently feel. Please circle the intensity of the feeling or idea that you are experiencing or thinking about. A higher score indicates greater intensity.

1	Irritability	Not at all	Slightly intense	Moderately intense	Intense	Extremely intense
2	Anxiety	1	2	3	4	5
3	Dysphoria	1	2	3	4	5
4	Restlessness	1	2	3	4	5
5	Unsatisfaction	1	2	3	4	5
6	Impatience	1	2	3	4	5
7	Frustration	1	2	3	4	5
8	Gaming urge	1	2	3	4	5
9	Inability to do other things	1	2	3	4	5
10	Preoccupation with gaming	1	2	3	4	5
11	Disinclination for activity	1	2	3	4	5
12	Boredom	1	2	3	4	5
13	Lack of motivation	1	2	3	4	5
14	Emptiness	1	2	3	4	5
15	Inability to relax	1	2	3	4	5

Supplement Table 1. The linear regression model regress withdrawal-related symptoms (WRS) and gaming craving against on Group effect (IGD versus regular gamer) and abstinence duration (long versus short) and regress them on Group effect and psychiatric comorbidity.

	B	St. error	Beta	T
WRS ^a				
Model 1				
Group effect ^b	12.06	2.60	0.48	4.65***
Abstinence duration ^c	-2.34	2.64	-0.09	-0.89
Interaction term	2.31	3.81	0.07	0.61
Model 2				
Group effect ^b	10.77	1.90	0.43	5.66***
ADHD ^d	5.21	2.03	0.20	2.57*
Emotional Comorbidity ^e	3.99	2.25	0.13	1.78
Gaming craving ^f				
Model 1				
Group effect ^b	17.01	2.32	0.61	7.32***
Abstinence duration ^c	-7.34	2.36	-0.26	-3.12**
Interaction term	2.11	3.41	0.06	0.62
Model 2				
Group effect ^b	19.53	1.87	0.70	10.47***
ADHD ^d	0.94	1.99	0.03	0.47
Emotional Comorbidity ^e	0.24	2.20	0.01	0.11

^a Score for Affective and Behavior Withdrawal Symptoms of Gaming Disorder Questionnaire.

^b Group effect: IGD group versus regular gamers.

^c Abstinence duration: duration less than 6 versus 6 h or more.

^d ADHD: comorbidity with attention deficit/hyperactivity disorder.

^e Emotional comorbidity: comorbidity with depressive disorder, generalized anxiety disorder or social anxiety disorder.

^f Questionnaire on Gaming Urge-Brief Version.

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Supplement Table 2. Difference in Withdrawal-Related Symptoms (WRS), gaming craving, severity of IGD, and heart rate variability between short and long withdrawal groups among regular gamers

	0–6 h (N = 267)	6–72 h (N = 43)	t test
	Mean ± SD	Mean ± SD	
WRS ^a	27.92 ± 9.44	25.58 ± 8.49	1.06
Gaming craving ^b	37.27 ± 9.88	29.93 ± 12.11	2.61*
Severity of IGD ^c	60.62 ± 14.30	53.00 ± 14.33	2.14*

^a Score for Affective and Behavior Withdrawal Symptoms of Gaming Disorder Questionnaire.

^b Questionnaire on Gaming Urge-Brief Version.

^c Chen Internet Addiction Scale-Gaming Version.

* $P < 0.05$.