Association between Internet gaming disorder and generalized anxiety disorder

CHAO-YANG WANG[1], YU-CHEN WU[2], CHEN-HSIANG SU[3], PAI-CHENG LIN[3], CHIH-HUNG KO[3,4,5] and JU-YU YEN[3,5,6]*

[1]Department of Psychiatry, Taoyuan Armed Forced General Hospital, Taoyuan, Taiwan
[2]Department of Nursing, Kaohsiung Municipal Ta-Tung Hospital, Kaohsiung Medical University, Kaohsiung City, Taiwan
[3]Department of Psychiatry, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung City, Taiwan
[4]Department of Psychiatry, Kaohsiung Municipal Hsiao-Kang Hospital, Kaohsiung Medical University, Kaohsiung City, Taiwan
[5]Faculty of Medicine, Department of Psychiatry, College of Medicine, Kaohsiung Medical University, Kaohsiung City, Taiwan
[6]Department of Psychiatry, Kaohsiung Municipal Ta-Tung Hospital, Kaohsiung Medical University, Kaohsiung City, Taiwan

Introduction: This study evaluates the association between generalized anxiety disorder (GAD) and Internet gaming disorder (IGD) and the role of behavior inhibition in young adults. *Methods:* We recruited 87 people with IGD and a control group of 87 people without a history of IGD. All participants underwent a diagnostic interview based on the fifth edition of *Diagnostic and Statistical Manual of Mental Disorders*, IGD and GAD criteria, and completed a questionnaire on behavior inhibition, depression, and anxiety. *Results:* Logistic regression revealed that adults with GAD were more likely (odds ratio = 8.11, 95% CI = 1.78−37.09) to have IGD than those without it. The OR decreased when controlling for behavior inhibition. IGD subjects with GAD had higher depressive and anxiety score than those without GAD. *Conclusions:* GAD was associated with IGD. Comorbid GAD can contribute to higher emotional difficulty. GAD should be well-assessed and interventions planned when treating young adults with IGD. Behavioral inhibition confounds the association between GAD and IGD. Further study is necessary to evaluate how to intervene in behavioral inhibitions to attenuate the risk of GAD and IGD comorbidity.

Keywords: behavior inhibition, comorbidity, generalized anxiety disorder, Internet gaming disorder

INTRODUCTION

Along with the popularization and progression of technology, the high availability of the Internet and the information it contains not only bring us convenience but also changes our daily lives. Despite the Internet's benefits, a loss of control over Internet use, defined as Internet addiction, might negatively affect life function and performance in our daily lives, family and peer relationships, and emotional stability (Anderson, 2001; Lin & Tsai, 2002; Ryu, Choi, Seo, & Nam, 2004; Young & Rogers, 1998). Internet gaming is one of the most popular online activities, and Internet gaming disorder (IGD) is the most prevalent subtype (57.5%) of Internet addiction (Kishi et al., 2009). IGD has been associated with a higher prevalence of anxiety disorder (Gentile et al., 2011). However, whether IGD is comorbid with generalized anxiety disorder (GAD) has not been well studied.

Internet gaming disorder (IGD)

IGD was first included in the fifth edition of appendix of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013) in May 2013 as a condition warranting further study. The classification of IGD is similar to gambling disorder and contains nine criteria: (a) preoccupation with Internet games; (b) withdrawal symptoms when Internet gaming is discontinued; (c) tolerance: the need to spend increasing amount of time engaged in Internet gaming; (d) unsuccessful attempts to control participation in Internet gaming; (e) loss of interest in hobbies and entertainment as a result of, and with the exception of, Internet gaming; (f) continued excessive use of Internet games, despite the knowledge of psychosocial problems; (g) deception of family members, therapists, or others regarding the amount of Internet gaming; (h) use of Internet gaming to escape or relieve a negative mood; and (i) loss of a significant relationship, job, or educational or career opportunity because of participation in Internet games (APA, 2013).

The diagnostic validity of the *DSM-5* criteria has been supported by an interview study (Ko et al., 2014). However, there are debates about the validity, reliability, and content of DSM-5 criteria of IGD (Griffiths et al., 2016; Király, Griffiths, & Demetrovics, 2015; Kuss, Griffiths, & Pontes, 2017). The characteristics and intricacies of each criterion should be evaluated and validated in the future (Király et al., 2017). Nevertheless, having a common tool for clinicians to

---

* Corresponding author: Ju-Yu Yen, MD, PhD; Department of Psychiatry, Kaohsiung Municipal Ta-Tung Hospital, Kaohsiung City 807, Taiwan; E-mail: yenjuyu@cc.kmu.edu.tw

---

diagnose IGD and for researchers to compare their results is useful (Petry et al., 2014). Thus, we recruited participants with IGD based on the *DSM-5* IGD criteria.

Generalized anxiety disorder (GAD)

GAD is characterized by excessive and persistent worrying and stress that is difficult to control and is often accompanied by insomnia, restlessness, muscle tension, and concentration problems. According to *DSM-5*, the symptoms must occur on the majority of days for at least 6 months. General anxiety disorder is one of the most common mental disorders in the community and primary care facilities (Wittchen et al., 2002), with a 4%–7% lifetime prevalence and 1%–4% reported annual incidence (Hoge, Ivkovic, & Fricchione, 2012; Katzman et al., 2014). The presence of comorbidity with major depression or other anxiety disorders has been commonly observed and associated with a poorer prognosis compared with isolated GAD (Kessler et al., 2008). This disorder may also be associated with increased rates of substance abuse. Although studies have suggested that those with GAD are prone to addictive behaviors, such as alcohol abuse, to cope with their anxiety (Smith & Book, 2008, 2010; Smith & Randall, 2012), whether they have a manifestly increased risk for IGD has yet to be evaluated.

Association between IGD and general anxiety disorder

Previous reports have suggested that Internet addiction is associated with various psychiatric disorders. Studies have shown a high comorbidity between Internet addiction and psychiatric disorders, especially affective disorders (e.g., depression) and anxiety disorders (e.g., GAD and social anxiety disorder) (Caplan, 2007; Cole & Griffiths, 2007; Lehenbauer-Baum et al., 2015; Morahan-Martin & Schumacher, 2003; Weinstein & Lejoyeux, 2010; Yen et al., 2012). Furthermore, a study of South Korean participants found that an IGD risk group had significantly higher anxiety symptom scores (Kim et al., 2016). As anxiety symptoms are the core presentation of GAD, we hypothesize that GAD is associated with IGD. In addition, comorbidity with GAD might further deteriorate the ability to cope with the negative consequences of addiction. This could contribute to a decline in emotional well-being . Thus, we hypothesized that those with IGD comorbid with GAD might manifest more anxiety and depression.

Associations between behavioral inhibition, IGD, and general anxiety disorder

Eysenck (1997) suggested that certain personality traits are prominent vulnerability factors for all types of addiction. According to Gray's reinforcement sensitivity theory, the behavioral inhibition system (BIS) responds to punishment and results in behavior withdrawal and arousal (Carver & White, 1994). Yen, Ko, Yen, Chen, and Chen (2009) reported that college students with Internet addiction had high BIS scores and for college students with high anxiety about immediate consequences, the Internet virtual world

provides an environment with fewer anxiety triggers than real-world activities, consequently promoting Internet use. Those with high BIS scores have a tendency to be sensitive to aversive results and are vulnerable to anxiety. High BIS scores are also reported to be a predisposing characteristic of social anxiety (Kasch, Rottenberg, Arnow, & Gotlib, 2002; Marcin & Nemeroff, 2003; Morgan et al., 2009; Schofield, Coles, & Gibb, 2009; Yen et al., 2012). These results suggest that behavior inhibition is associated with both IGD and GAD. We hypothesized that if IGD is comorbid with GAD, behavior inhibition would be involved in the association between GAD and IGD.

Study objective

We hypothesized that IGD is associated with GAD and that both disorders are associated with behavior inhibition. Those who have IGD with GAD as a comorbid condition could have pronounced depression and anxiety. Under these hypotheses, the study aims to evaluate (a) the association between IGD and GAD; (b) the effect of behavior inhibition in the association between IGD and GAD; and (c) the association between GAD, depression, and anxiety among subjects with IGD.

METHODS

Participants

The participants included those who currently had IGD (IGD group) and those who had never had IGD (control group). All participants were recruited by advertisement from September 2012 to October 2013. The advertisement was posted on the most popular bulletin board system in Taiwan. The recruitment criteria in the IGD group were as follows: (a) young adults of age 20–30 years and an educational level greater than 9 years; (b) those who played Internet games for 4 or more hours per day on weekdays and 8 or more hours per day on weekends or 40 or more hours per week; and (c) those who had maintained a pattern of Internet gaming for more than 2 years. Those participants responded to the advertisement and met all three criteria were invited to participate in this study after informed consent was obtained. Furthermore, they were interviewed by a psychiatrist based on the IGD criteria of *DSM-5* to determine the diagnosis of IGD could be applied. Those diagnosed with IGD were classified as the participants of the IGD group.

When we enrolled a participant in the IGD group, we enrolled a corresponding participant – of the same gender, educational level, and age (within a range of 1 year) – in the control group by posting an advertisement on the bulletin board system. The recruitment criterion of the participants in the control group was that their non-essential Internet use was less than 4 hr/day. They were classified into the control group after a diagnostic interview conducted by the psychiatrist. All participants underwent a three-part interview: (a) a diagnostic interview with a psychiatrist based on the Chinese version of *Mini-International Neuropsychiatric Interview* (*M.I.N.I.*) to determine the existence of GAD and

exclude those diagnosed with psychotic disorders, bipolar I disorder, and substance use disorders; (b) a history-taking interview to exclude those who used psychotropic medication were mentally retarded, had a severe physical disorder, or disclosed a previous brain injury; (c) an IGD-determination interview to ensure that the participants of the control group had never met the criteria for IGD.

Measures

The diagnostic criteria of IGD in DSM-5. Nine items comprise the diagnostic criteria of IGD in the *DSM-5*: preoccupation, withdrawal, tolerance, unsuccessful attempts to control, loss of other interests, continued excessive use despite psychosocial problems, deception regarding online gaming, escape, and functional impairment (APA, 2013). We developed a semistructured interview schedule to determine whether five or more of the *DSM-5* criteria of IGD were present, and such participants were classified as the IGD group. The threshold of the *DSM-5*'s IGD criteria was supported by a previous study (Király et al., 2017; Ko et al., 2014).

Chinese version of the M.I.N.I. We conducted a diagnostic interview based on the modules of GAD, psychotic disorders, bipolar I disorder, and substance use disorders using the Chinese version of the M.I.N.I. (Sheehan et al., 1998) to determine the existence of GAD and to exclude psychiatric disorders.

Center for Epidemiological Studies' Depression Scale (CES-D). The 20-item Mandarin Chinese version (Chien & Cheng, 1985) of *CES-D* (Radloff, 1977) is a self-administered evaluation assessing participants' frequency of depressive symptoms over the previous week. Cronbach's α of *CES-D* in this study was .92 and was utilized to evaluate depression. Skewness and kurtosis were 0.87 and 0.48, respectively.

Penn State Worry Questionnaire (PSWQ). The PSWQ (Meyer, Miller, Metzger, & Borkovec, 1990) has 16 items, and each item is rated on a scale from 1 ("not at all typical of me") to 5 ("very typical of me"). Eleven items are worded to evaluate whether pathological worry is a problem. The remaining five items are worded to determine whether worry is not a problem and is scored reversely. The *PSWQ* was found to significantly differentiate college samples which met all, some, or none of the revised third edition of *DSM* (American Psychiatric Association, 1987) diagnostic criteria for GAD, providing good internal consistency and validity and a valid measure to assess anxiety symptoms. Cronbach's α of *PSWQ* in this study was .92 and used to evaluate the anxiety symptoms; skewness and kurtosis were 0.19 and −0.06, respectively.

Behavior inhibition system and behavior approach system scales (Gray, 1991). The Behavioral Inhibition System and Behavioral Approach System Scales (BIS/BAS scales) (Gray, 1991) were designed to assess individual differences in the sensitivity of the two motivational systems proposed by Gray (1970). The BIS scale measured the degree to which respondents expected to feel anxiety when confronted with cues for punishment. The test–retest reliability of the BIS subscales was 0.66 (Carver & White, 1994). We used the BIS scale to assess the vulnerability to anxiety. The

higher score indicates the higher behavior inhibition. Cronbach's α of the BIS scale was .78 in this study; skewness and kurtosis were −0.2 and 0.52, respectively.

Procedures

All the matched participants from the IGD and control groups underwent a diagnostic interview by a psychiatrist to determine the existence of each diagnostic criterion of GAD. All participants completed the aforementioned assessments after the diagnostic interview.

Statistical analysis

We evaluated the association between IGD and GAD with χ^2 and logistic regression analysis. Then, we evaluated the differences in depression, anxiety, and behavior inhibition between subjects with IGD and those without using an independent t test. The independent t test was used to evaluate the association between behavior inhibition and GAD. Next, we evaluated the association between IGD and GAD with logistic regression under the control of behavior inhibition. Finally, we evaluated the differences in depression, anxiety, and behavior inhibition between IGD participants with GAD and those without using an independent t test. The p value less than .05 was considered significant for all analyses, which were performed using the SPSS software package.

Ethics

A total of 87 participants in the IGD group and 87 in the control group were recruited into this study. A detailed explanation of the study was given; subsequently, informed consent was obtained from all participants. This study was approved by the Institutional Review Board of Kaohsiung Medical University Hospital.

RESULTS

Comparisons of depression, anxiety, and behavior inhibition between IGD and control groups

A total of 87 participants in the IGD group and 87 participants in the control group were recruited into this study. Table 1 presents the differences in gender, age, educational level, depression, anxiety, behavior inhibition, and behavior activation between the IGD and control groups. There were no significant differences in gender, age, and educational level between the two groups. The IGD group had higher scores on depression, anxiety, and behavior inhibition.

Association between IGD and general anxiety disorder

χ^2 analysis revealed the significant association between IGD and GAD. Model I of the logistic regression in Table 2 is to regress IGD on GAD to determine the odds ratio (OR) of IGD among participants with GAD, controlling for age, gender, and educational level. Model I demonstrates that

Table 1. Demographic data, depression, anxiety, behavior inhibition, and behavior activation among adults with Internet gaming disorder (IGD) and controls

	IGD diagnosis		
Variables	Control ($N = 87$) N (%)	IGD ($N = 87$) N (%)	χ^2 test
General anxiety disorder			
Yes ($N = 16$)	2 (12.5)	14 (87.5)	9.911**
No ($N = 158$)	85 (53.8)	73 (46.2)	
	Mean $\pm$ SD	Mean $\pm$ SD	*t*-test
Age (years)	23.38 $\pm$ 2.40	23.29 $\pm$ 2.34	−0.256
Education level (years)	16.14 $\pm$ 1.22	15.93 $\pm$ 1.15	−1.151
Depression[a]	12.01 $\pm$ 7.90	20.44 $\pm$ 10.01	6.163***
Anxiety[b]	46.72 $\pm$ 10.00	53.61 $\pm$ 10.86	4.350***
Behavior inhibition[c]	19.75 $\pm$ 2.85	21.24 $\pm$ 3.36	3.168**

Note.[a]Depression: the score of the Center for Epidemiological Studies' Depression Scale (CES-D).
[b]Anxiety: the score of the Penn State Worry Questionnaire (PSWQ).
[c]Behavior inhibition: the score of the BIS subscale of the Behavioral Inhibition System and Behavioral Approach System Scales (BIS/BAS scales).
**$p < .005$. ***$p < .001$.

adults with GAD were more likely (OR = 8.11, 95% CI = 1.78−37.09) to have IGD than those without GAD.

Association between IGD and general anxiety disorder with control of behavior inhibition

Behavior inhibition was included as an independent variable in regression Model I of Table 2 and named Model II. The OR of adults with GAD to have IGD decreased to 5.6 (95% CI = 1.19−26.32) when behavior inhibition was input to the regression model (Model II in Table 2). In addition, an independent *t* test demonstrated that subjects with GAD had

a higher score in BIS ($t = 3.76$, $p < .001$). These results indicate that behavior inhibition is associated with both IGD and GAD. General anxiety disorder is also significantly associated with IGD in the final model (Model II in Table 2). According to the mediating theory of Baron and Kenny (1986), this result indicated that behavior inhibition partially mediated the association between IGD and GAD. As the Wald's value of behavior inhibition was higher than that of GAD, it had a stronger effect on IGD than GAD in the final model.

Finally, among subjects with IGD, comorbidity with GAD was associated with higher depression and anxiety than those without GAD (Table 3).

Table 2. Logistic regression for the association between generalized anxiety disorder (GAD) and Internet gaming disorder (IGD)

Variables	Wald	Exp(β)	95% CI
IGD: Model I[a]			
Gender	0.01	0.95	0.44–2.08
Age (year)	0.14	1.03	0.89–1.18
Education level (year)	1.15	0.85	0.64–1.14
GAD	7.29**	8.11	1.78–37.09
Model II[b]			
Gender	0.81	0.89	0.40–1.98
Age (year)	0.85	1.07	0.93–1.24
Education level (year)	1.84	0.81	0.60–1.10
GAD	4.76*	5.60	1.19–26.32
Behavior inhibition[c]	6.61*	1.15	1.03–1.29

Note. [a]Model I: we regress IGD on GAD, controlling for age, gender, and educational level.
[b]Model II: behavior inhibition was included as an independent variable to enter the regression Model I.
[c]Behavior inhibition: the score of BIS subscale of the Behavioral Inhibition System and Behavioral Approach System Scales (BIS/BAS scales).
*$p < .05$. **$p < .005$.

Table 3. *t*-test for the association between generalized anxiety disorder (GAD), depression, anxiety, behavior inhibition, and behavior activation among adults with IGD

	Generalized anxiety disorder		
Variables	Yes ($N = 14$) Mean $\pm$ SD	No ($N = 73$) Mean $\pm$ SD	*t*-test
Age(year)	22.93 $\pm$ 1.73	23.36 $\pm$ 2.44	−0.6.25
Education level(year)	15.71 $\pm$ 1.27	15.97 $\pm$ 1.13	−0.769
Depression[a]	28.86 $\pm$ 9.92	18.82 $\pm$ 9.24	3.679***
Anxiety[b]	60.71 $\pm$ 9.06	52.25 $\pm$ 10.69	2.775**
Behavior inhibition[c]	22.86 $\pm$ 2.38	20.93 $\pm$ 3.44	2.001*

Note. [a]Depression: the score of the Center for Epidemiological Studies' Depression Scale (CES-D).
[b]Anxiety: the score of the Penn State Worry Questionnaire (PSWQ).
[c]Behavior inhibition: the score of BIS subscale of the Behavioral Inhibition System and Behavioral Approach System Scales (BIS/BAS scales).
*$p < .05$. **$p < .005$. ***$p < .001$.

DISCUSSION

Association between IGD and general anxiety disorder

Internet addiction has previously been associated with anxiety disorder in adults and adolescents (Caplan, 2007; Morahan-Martin & Schumacher, 2003; Winstanley, Eagle, & Robbins, 2006; Yen et al., 2012). This present investigation is the first to reveal the positive association between IGD and GAD: the participants with IGD were more likely to be comorbid with GAD compared with those without IGD. The association persisted after controlling for both age and educational level, indicating that the association could not solely be explained by age or educational level. Furthermore, subjects with IGD had higher anxiety symptoms, suggesting that subjects with IGD had not only high anxiety symptoms but also a higher risk of comorbidity with GAD.

A previous study suggested that the primary motivations for online gaming were "escape" and "coping" (Kim et al., 2016). Another study using the Internet Motive Questionnaire for Adolescents also demonstrated that "coping" was a major motivation for online gaming use in subjects diagnosed with IGD (Bischof-Kastner, Kuntsche, & Wolstein, 2014). Evidence shows that worry evokes and sustains a negative affect among subjects with IGD, thereby precluding sharp increases in negative emotion and demonstrating their avoidance behavior (Newman, Llera, Erickson, Przeworski, & Castonguay, 2013). Online gaming provided a virtual world for the player to escape and forget about their worries in real life. To keep avoiding the real world, subjects with GAD might escape to the Internet and spend excessive time online gaming. Without effective intervention for their anxiety symptoms, repeatedly escaping to online gaming could increase the risk of addiction to online gaming.

On the contrary, excessive online gaming could result in negative consequences, such as academic failure or inadequate social interaction. These might make some vulnerable subjects overtly worry about their performance and social interaction. The vicious cycle of negative consequences and escaping behavior could contribute to the association between IGD and GAD. A previous study found that escape mediated the association between psychiatric symptoms and problematic online gaming (Kiraly, Urban, et al., 2015). Regarding the negative effect of comorbid disorder on the course of the addictive disorder, more attention and intervention should be paid to GAD when treating subjects with IGD to prevent the vicious cycle.

Role of behavior inhibition in the association between IGD and general anxiety disorder

Comorbidity between two disorders might indicate a causal relationship, because they share the same associated factors or common etiology and bidirectional interaction (Mueser, Drake, & Wallach, 1998). We evaluated the possible confounding factors playing a role in the association between IGD and GAD. In this study, our mediational model hypothesized that the GAD was associated with the mediating factor, which in turn was associated with IGD. The mediating factors served to explore the mechanism of the

association between these two disorders and may elucidate the psychopathology of Internet addiction.

Behavior inhibition represents sensitivity to aversive stimuli. A previous review suggested that behavioral inhibition could be a stable characteristic from childhood and a risk factor for anxiety disorders when subjects grow up (Svihra & Katzman, 2004). In line with a previous claim (Yen et al., 2009), we found that subjects with GAD had higher behavior inhibition. In addition, we found that behavior inhibition is associated with IGD. Behavior inhibition indicates the consistent tendency to demonstrate fear and withdrawal in novel situations (Svihra & Katzman, 2004). High behavior inhibition could prohibit subjects from trying activities and interaction in real-world social interactions. However, anonymity, a lack of direct physical harm, and the ability to enter and leave without restriction in online gaming could allow the user to feel relief from immediate anxiety. Furthermore, online gaming is designed to satisfy the user in a group behavioral setting. Subjects with higher behavior inhibition may experience fewer aversive situations in online gaming. Thus, behavior inhibition could play an important role in retaining effect on vulnerability to IGD.

In this study, behavior inhibition partially mediated the association between IGD and the diagnosis of GAD, indicating that behavior inhibition plays a role in the comorbidity of IGD and GAD. Gray (1978, 1981, 1987, 1990) has also held that BIS functioning is responsible for the experience of negative feelings, such as fear, anxiety, frustration, and sadness in response to these cues. Regarding individual differences in personality, greater BIS sensitivity should be reflected in greater susceptibility to anxiety, provided the person is exposed to the proper situational cues. The participants with GAD had higher behavior inhibition, which might make them prone to the desire to escape from real-world relationships and interaction and to consequently use online gaming as an alternative means to facelessly interact with others or relieve their emotional difficulty. However, regarding their high behavior inhibition, they could experience higher anxiety symptoms when they want to change their social interaction from online gaming to the real world. This would result in a vicious cycle and contribute to the addiction process. Thus, counseling for behavior inhibition should be provided to subjects with IGD with GAD. In addition, GAD affects IGD even under the control of behavior addiction. Apart from intervention for behavior inhibition, we must assess and treat GAD among subjects with IGD.

Role of depression in the association between IGD and general anxiety disorder

This study showed that the participants with IGD had higher scores on the depression scale, which has been reported to be associated with increased levels of personal Internet use because it provides an environment without real-life interpersonal difficulties (Cheng & Li, 2014; Ho et al., 2014; Yen, Ko, Yen, Wu, & Yang, 2007; Young & Rogers, 1998). In addition, since GAD and depression share the same genetic mechanisms and display substantial comorbidity in both clinical and epidemiological samples (Kendler, 1996;

Kendler, Neale, Kessler, Heath, & Eaves, 1992; Moffitt et al., 2007), patients with GAD had higher severity of depression; this was also true in this study.

We also found that participants with IGD with GAD had higher depressive symptoms than those without. Addiction to Internet gaming might result in negative psychosocial consequences (Ko, et al., 2014). As subjects with GAD had higher behavior inhibition (Fox, Henderson, Marshall, Nichols, & Ghera, 2005), they might be more sensitive to these negative consequences.

However, any intervention must focus on finding alternative activities to replace heavy online gaming use. The anxiety symptoms of GAD and behavior inhibition characteristics might prevent trying new activities and could result in the vicious cycle and make them more depressed. The inadequate coping strategy among those with GAD (Ko, et al., 2014; Kuss, Louws, & Wiers, 2012) might increase their desire escape from the real world to online gaming to prevent negative feelings. In addition, behavior inhibition and depression are major contributors to comorbid GAD and IGD. Moreover, we demonstrated that individuals with GAD and IGD have higher behavior inhibition, depression, and anxiety severity than those with IGD and without GAD do. Individuals with GAD may play Internet games to satisfy their need for achievement and social support, experience fewer aversive situations, and compensate for their difficulties in coping with the real world. Therefore, aggressive intervention for both disorders should be provided as soon as possible to attenuate the accompanying depression in both disorders.

LIMITATIONS

This study had several limitations. First, the cross-sectional research design of the study could not confirm potentially causal relationships among IGD, behavior inhibition, and GAD. Second, the diagnosis of IGD was based on only a diagnostic interview without information provided by the family, which could have resulted in a misclassification of this diagnosis. Third, the sample was small and included a higher proportion of college students than exists in the general population; hence, some meaningful associations may not have been detected as statistically significant and the findings may not be generalizable. In addition, the small number of participants limits the possibility to compare the role of comorbid GAD on depression, anxiety, and behavior inhibition between the IGD and control groups. Finally, lack of control for other confounding variables may have affected the results. Future studies should evaluate and control for the life events, social support, and other personality characteristics that might affect IGD or GAD.

CONCLUSIONS

We found that participants with IGD were more likely to have GAD. Behavior inhibition was associated with GAD among participants with IGD and mediated the association between IGD and GAD. GAD should be assessed and appropriate interventions should be designed for subjects with IGD, particularly among those with behavior inhibition. Effective management of behavior inhibition and anxiety counseling to attenuate the severity of comorbid GAD are therefore suggested when treating subjects with IGD. In addition, participants presenting IGD comorbid with GAD had higher depressive symptoms. Early and aggressive intervention for both disorders is necessary to prevent a self-perpetuating cycle. Ultimately, larger longitudinal studies would be useful to understand how behavior inhibition affects IGD and GAD. More research is needed to clarify the temporal relationships between IGD, GAD, and the factors that modify the risk.

Authors' contribution: C-YW wrote the first draft of the manuscript. Y-CW and C-HS managed the literature searches and analyses. P-CL and C-HK undertook the statistical analysis. C-HK and J-YY designed the study and wrote the protocol. J-YY approved the final manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest: There is no conflict of interest with the manuscript.

REFERENCES

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders: DSM III-R* (3rd ed., rev.). Washington, DC: American Psychiatric Association.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). Washington, DC: American Psychiatric Association.

Anderson, K. J. (2001). Internet use among college students: An exploratory study. *Journal of American College Health, 50*(1), 21–26. doi:10.1080/07448480109595707

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173–1182. doi:10.1037/0022-3514.51.6.1173

Bischof-Kastner, C., Kuntsche, E., & Wolstein, J. (2014). Identifying problematic Internet users: Development and validation of the Internet Motive Questionnaire for Adolescents (IMQ-A). *Journal of Medical Internet Research, 16*(10), e230. doi:10.2196/jmir.3398

Caplan, S. E. (2007). Relations among loneliness, social anxiety, and problematic Internet use. *CyberPsychology & Behavior, 10*(2), 234–242. doi:10.1089/cpb.2006.9963

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of*

Personality and Social Psychology, 67(2), 319–333. doi:10.1037/0022-3514.67.2.319

Cheng, C., & Li, A. Y. (2014). Internet addiction prevalence and quality of (real) life: A meta-analysis of 31 nations across seven world regions. *Cyberpsychology, Behavior and Social Networking, 17*(12), 755–760. doi:10.1089/cyber.2014.0317

Chien, C. P., & Cheng, T. A. (1985). Depression in Taiwan: Epidemiological survey utilizing CES-D. *Seishin Shinkeigaku Zasshi, 87*(5), 335–338.

Cole, H., & Griffiths, M. D. (2007). Social interactions in massively multiplayer online role-playing gamers. *CyberPsychology & Behavior, 10*(4), 575–583. doi:10.1089/cpb.2007.9988

Eysenck, H. J. (1997). Addiction, personality and motivation. *Human Psychopharmacology: Clinical and Experimental, 12*(Suppl 2), S79–S87. doi:10.1002/(SICI)1099-1077(199706)12:2+<S79::AID-HUP905>3.0.CO;2-T

Fox, N. A., Henderson, H. A., Marshall, P. J., Nichols, K. E., & Ghera, M. M. (2005). Behavioral inhibition: Linking biology and behavior within a developmental framework. *Annual Review of Psychology, 56*(1), 235–262. doi:10.1146/annurev.psych.55.090902.141532

Gentile, D. A., Choo, H., Liau, A., Sim, T., Li, D., Fung, D., & Khoo, A. (2011). Pathological video game use among youths: A two-year longitudinal study. *Pediatrics, 127*(2), e319–e329. doi:10.1542/peds.2010-1353

Gray, J. A. (1970). The psychophysiological basis of introversion-extraversion. *Behaviour Research and Therapy, 8*(3), 249–266. doi:10.1016/0005-7967(70)90069-0

Gray, J. A. (1978). The neuropsychology of anxiety. *British Journal of Psychology, 69*(4), 417–434. doi:10.1111/j.2044-8295.1978.tb02118.x

Gray, J. A. (1981). A critique of Eysenck's theory of personality. In E. J. Eysenck (Ed.), *A model for personality* (pp. 246–276). Berlin/Heidelberg: Springer.

Gray, J. A. (1987). *The psychology of fear and stress*. Cambridge, UK: Cambridge University Press.

Gray, J. A. (1990). Brain systems that mediate both emotion and cognition. *Cognition and Emotion, 4*(3), 269–288. doi:10.1080/02699939008410799

Gray, J. A. (1991). The neuropsychology of temperament. In J. Strelau & A. Angleitner (Eds.), *Explorations in temperament: International perspectives on theory and measurement* (pp. 105–128). Boston, MA: Springer US.

Griffiths, M. D., van Rooij, A. J., Kardefelt-Winther, D., Starcevic, V., Kiraly, O., Pallesen, S., Muller, K., Dreier, M., Carras, M., Prause, N., King, D. L., Aboujaoude, E., Kuss, D. J., Pontes, H. M., Fernandez, O. L., Nagygyorgy, K., Achab, S., Billieux, J., Quandt, T., Carbonell, X., Ferguson, C. J., Hoff, R. A., Derevensky, J., Haagsma, M. C., Delfabbro, P., Coulson, M., Hussain, Z., & Demetrovics, Z. (2016). Working towards an international consensus on criteria for assessing Internet gaming disorder: A critical commentary on Petry et al. (2014). *Addiction, 111*(1), 167–175. doi:10.1111/add.13057

Ho, R. C., Zhang, M. W., Tsang, T. Y., Toh, A. H., Pan, F., Lu, Y., Cheng, C., Yip, P. S., Lam, L. T., Lai, C. M., Watanabe, H., & Mak, K. K. (2014). The association between Internet addiction and psychiatric co-morbidity: A meta-analysis. *BMC Psychiatry, 14,* 183. doi:10.1186/1471-244X-14-183

Hoge, E. A., Ivkovic, A., & Fricchione, G. L. (2012). Generalized anxiety disorder: Diagnosis and treatment. *BMJ, 345,* e7500. doi:10.1136/bmj.e7500

Kasch, K. L., Rottenberg, J., Arnow, B. A., & Gotlib, I. H. (2002). Behavioral activation and inhibition systems and the severity and course of depression. *Journal of Abnormal Psychology, 111*(4), 589–597. doi:10.1037/0021-843X.111.4.589

Katzman, M. A., Bleau, P., Blier, P., Chokka, P., Kjernisted, K., Van Ameringen, M., Canadian Anxiety Guidelines Initiative Group on behalf of the Anxiety Disorders Association of Canada/Association Canadienne des troubles anxieux and McGill University, Antony, M. M., Bouchard, S., Brunet, A., Flament, M., Grigoriadis, S., Mendlowitz, S., O'Connor, K., Rabheru, K., Richter, P. M., Robichaud, M., & Walker, J. R. (2014). Canadian clinical practice guidelines for the management of anxiety, posttraumatic stress and obsessive-compulsive disorders. *BMC Psychiatry, 14*(Suppl 1), S1. doi:10.1186/1471-244X-14-S1-S1

Kendler, K. S. (1996). Major depression and generalised anxiety disorder same genes, (Partly) different environments – Revisited. *The British Journal of Psychiatry, 168*(Suppl 30), 68–75.

Kendler, K. S., Neale, M. C., Kessler, R. C., Heath, A. C., & Eaves, L. J. (1992). Major depression and generalized anxiety disorder: Same genes, (partly) different environments? *Archives of General Psychiatry, 49*(9), 716–722. doi:10.1001/archpsyc.1992.01820090044008

Kessler, R. C., Gruber, M., Hettema, J. M., Hwang, I., Sampson, N., & Yonkers, K. A. (2008). Co-morbid major depression and generalized anxiety disorders in the National Comorbidity Survey follow-up. *Psychological Medicine, 38*(3), 365–374. doi:10.1017/S0033291707002012

Kim, N. R., Hwang, S. S., Choi, J. S., Kim, D. J., Demetrovics, Z., Király, O., Nagygyörgy, K., Griffiths, M. D., Hyun, S. Y., Youn, H. C., & Choi, S. W. (2016). Characteristics and psychiatric symptoms of Internet gaming disorder among adults using self-reported DSM-5 criteria. *Psychiatry Investigation, 13*(1), 58–66. doi:10.4306/pi.2016.13.1.58

Király, O., Griffiths, M. D., & Demetrovics, Z. (2015). Internet gaming disorder and the DSM-5: Conceptualization, debates, and controversies. *Current Addiction Reports, 2*(3), 254–262. doi:10.1007/s40429-015-0066-7

Kiraly, O., Sleczka, P., Pontes, H. M., Urban, R., Griffiths, M. D., & Demetrovics, Z. (2017). Validation of the ten-item Internet Gaming Disorder Test (IGDT-10) and evaluation of the nine DSM-5 Internet gaming disorder criteria. *Addictive Behaviors, 64,* 253–260. doi:10.1016/j.addbeh.2015.11.005

Kiraly, O., Urban, R., Griffiths, M. D., Agoston, C., Nagygyorgy, K., Kokonyei, G., & Demetrovics, Z. (2015). The mediating effect of gaming motivation between psychiatric symptoms and problematic online gaming: An online survey. *Journal of Medical Internet Research, 17*(4), e88. doi:10.2196/jmir.3515

Kishi, T., Tsunoka, T., Ikeda, M., Kawashima, K., Okochi, T., Kitajima, T., Kinoshita, Y., Okumura, T., Yamanouchi, Y., Inada, T., Ozaki, N., & Iwata, N. (2009). Serotonin 1A receptor gene and major depressive disorder: An association study and meta-analysis. *Journal of Human Genetics, 54*(11), 629–633. doi:10.1038/jhg.2009.84

Ko, C. H., Yen, J. Y., Chen, S. H., Wang, P. W., Chen, C. S., & Yen, C. F. (2014). Evaluation of the diagnostic criteria of Internet gaming disorder in the DSM-5 among young adults in Taiwan. *Journal of Psychiatric Research, 53,* 103–110. doi:10.1016/j.jpsychires.2014.02.008

Kuss, D. J., Griffiths, M. D., & Pontes, H. M. (2017). Chaos and confusion in DSM-5 diagnosis of Internet gaming disorder: Issues, concerns, and recommendations for clarity in the field. *Journal of Behavioral Addictions, 6*(2), 103–109. doi:10.1556/2006.5.2016.062

Kuss, D. J., Louws, J., & Wiers, R. W. (2012). Online gaming addiction? Motives predict addictive play behavior in massively multiplayer online role-playing games. *Cyberpsychology, Behavior and Social Networking, 15*(9), 480–485. doi:10.1089/cyber.2012.0034

Lehenbauer-Baum, M., Klaps, A., Kovacovsky, Z., Witzmann, K., Zahlbruckner, R., & Stetina, B. U. (2015). Addiction and engagement: An explorative study toward classification criteria for Internet gaming disorder. *Cyberpsychology, Behavior and Social Networking, 18*(6), 343–349. doi:10.1089/cyber.2015.0063

Lin, S. S. J., & Tsai, C. C. (2002). Sensation seeking and Internet dependence of Taiwanese high school adolescents. *Computers in Human Behavior, 18*(4), 411–426. doi:10.1016/S0747-5632(01)00056-5

Marcin, M. S., & Nemeroff, C. B. (2003). The neurobiology of social anxiety disorder: The relevance of fear and anxiety. *Acta Psychiatrica Scandinavica. Supplementum, 108*(s417), 51–64. doi:10.1034/j.1600-0447.108.s417.4.x

Meyer, T. J., Miller, M. L., Metzger, R. L., & Borkovec, T. D. (1990). Development and validation of the Penn State Worry Questionnaire. *Behaviour Research and Therapy, 28*(6), 487–495. doi:10.1016/0005-7967(90)90135-6

Moffitt, T. E., Harrington, H., Caspi, A., Kim-Cohen, J., Goldberg, D., Gregory, A. M., & Poulton, R. (2007). Depression and generalized anxiety disorder: Cumulative and sequential comorbidity in a birth cohort followed prospectively to age 32 years. *Archives of General Psychiatry, 64*(6), 651–660. doi:10.1001/archpsyc.64.6.651

Morahan-Martin, J., & Schumacher, P. (2003). Loneliness and social uses of the Internet. *Computers in Human Behavior, 19*(6), 659–671. doi:10.1016/S0747-5632(03)00040-2

Morgan, B. E., van Honk, J., Hermans, E. J., Scholten, M. R., Stein, D. J., & Kahn, R. S. (2009). Gray's BIS/BAS dimensions in non-comorbid, non-medicated social anxiety disorder. *The World Journal of Biological Psychiatry, 10*(4 Pt 3), 925–928. doi:10.1080/15622970802571695

Mueser, K. T., Drake, R. E., & Wallach, M. A. (1998). Dual diagnosis: A review of etiological theories. *Addiction Behaviors, 23*(6), 717–734. doi:10.1016/S0306-4603(98)00073-2

Newman, M. G., Llera, S. J., Erickson, T. M., Przeworski, A., & Castonguay, L. G. (2013). Worry and generalized anxiety disorder: A review and theoretical synthesis of evidence on nature, etiology, mechanisms, and treatment. *Annual Review of Clinical Psychology, 9*(1), 275–297. doi:10.1146/annurev-clinpsy-050212-185544

Petry, N. M., Rehbein, F., Gentile, D. A., Lemmens, J. S., Mößle, T., Bischof, G., Tao, R., Fung, D. S., Borges, G., Auriacombe, M., González Ibáñez, A., Tam, P., & O'Brien, C. P. (2014). An international consensus for assessing Internet gaming disorder using the new DSM-5 approach. *Addiction, 109*(9), 1399–1406. doi:10.1111/add.12457

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*(3), 385–401. doi:10.1177/014662167700100306

Ryu, E. J., Choi, K. S., Seo, J. S., & Nam, B. W. (2004). [The relationships of Internet addiction, depression, and suicidal ideation in adolescents]. *Taehan Kanho Hakhoe Chi, 34*(1), 102–110. doi:10.4040/jkan.2004.34.1.102

Schofield, C. A., Coles, M. E., & Gibb, B. E. (2009). Retrospective reports of behavioral inhibition and young adults' current symptoms of social anxiety, depression, and anxious arousal. *Journal of Anxiety Disorders, 23*(7), 884–890. doi:10.1016/j.janxdis.2009.05.003

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *The Journal of Clinical Psychiatry, 59*(Suppl 20), 22–33; quiz 34–57.

Smith, J. P., & Book, S. W. (2008). Anxiety and substance use disorders: A review. *The Psychiatric Times, 25*(10), 19–23.

Smith, J. P., & Book, S. W. (2010). Comorbidity of generalized anxiety disorder and alcohol use disorders among individuals seeking outpatient substance abuse treatment. *Addiction Behaviors, 35*(1), 42–45. doi:10.1016/j.addbeh.2009.07.002

Smith, J. P., & Randall, C. L. (2012). Anxiety and alcohol use disorders: Comorbidity and treatment considerations. *Alcohol Research, 34*(4), 414–431.

Svihra, M., & Katzman, M. A. (2004). Behavioural inhibition: A predictor of anxiety. *Paediatrics & Child Health, 9*(8), 547–550. doi:10.1093/pch/9.8.547

Weinstein, A., & Lejoyeux, M. (2010). Internet addiction or excessive Internet use. *The American Journal of Drug and Alcohol Abuse, 36*(5), 277–283. doi:10.3109/00952990.2010.491880

Winstanley, C. A., Eagle, D. M., & Robbins, T. W. (2006). Behavioral models of impulsivity in relation to ADHD: Translation between clinical and preclinical studies. *Clinical Psychology Review, 26*(4), 379–395. doi:10.1016/j.cpr.2006.01.001

Wittchen, H. U., Kessler, R. C., Beesdo, K., Krause, P., Hofler, M., & Hoyer, J. (2002). Generalized anxiety and depression in primary care: Prevalence, recognition, and management. *The Journal of Clinical Psychiatry, 63*(Suppl 8), 24–34.

Yen, J. Y., Ko, C. H., Yen, C. F., Chen, C. S., & Chen, C. C. (2009). The association between harmful alcohol use and Internet addiction among college students: Comparison of personality. *Psychiatry and Clinical Neurosciences, 63*(2), 218–224. doi:10.1111/j.1440-1819.2009.01943.x

Yen, J. Y., Ko, C. H., Yen, C. F., Wu, H. Y., & Yang, M. J. (2007). The comorbid psychiatric symptoms of Internet addiction: Attention deficit and hyperactivity disorder (ADHD), depression, social phobia, and hostility. *The Journal of Adolescent Health, 41*(1), 93–98. doi:10.1016/j.jadohealth.2007.02.002

Yen, J. Y., Yen, C. F., Chen, C. S., Wang, P. W., Chang, Y. H., & Ko, C. H. (2012). Social anxiety in online and real-life interaction and their associated factors. *Cyberpsychology, Behavior and Social Networking, 15*(1), 7–12. doi:10.1089/cyber.2011.0015

Young, K. S., & Rogers, R. C. (1998). The relationship between depression and Internet addiction. *CyberPsychology & Behavior, 1*(1), 25–28. doi:10.1089/cpb.1998.1.25