



Risk factors associated with online game addiction: A hierarchical model



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ABSTRACT

Online gaming addiction has been increasingly recognized as a mental disorder. However, the predictive factors that lead to online gaming addiction are not well established. The aim of this study was to identify factors that may influence the development of online gaming addiction. A total of 263 patients with problematic online gaming addiction (255 males (97%) and 8 females (3%), age: mean = 20.4 ± 5.8 years) and 153 healthy comparison subjects (118 males (77%) and 35 females (23%), age: 21.2 ± 5.5 years, range) were recruited for participation in the current study. Hierarchical logistic regression analyses among each set of variables were conducted. Individual factors (sex and age), cognitive factors (IQ and perseverative errors), psychopathological conditions (ADHD, depression, anxiety, and impulsivity), and social interaction factors (family environment, social anxiety, and self-esteem) were evaluated in a stepwise fashion. All four factors were associated with online gaming addiction, with psychopathological conditions being the strongest risk factors for the addiction. Individual factors, psychological factors, and social interactions were associated with the development of pure online gaming addiction. As before, psychological factors (attention, mood, anxiety and impulsivity) were the strongest risk factors for online gaming addiction in patients with pure online gaming addiction. Psychopathologies, including ADHD and depression, were the strongest factors associated with the development of online gaming addiction in individuals.

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1. Introduction

Recently, it has been suggested that internet addiction is a mental health problem (Lam, Peng, Mai, & Jing, 2009). Internet addiction may impair daily life, academic performance, family relationships, and emotional development, particularly among adolescents. Since 1996, when the concept of “internet addiction” was introduced as a new clinical disorder, internet addiction has been studied in terms of the physical and psychological consequences, particularly in China, Korea, and Taiwan. However, the causes or aggravating factors that lead to internet addiction remain unknown, although many studies have attempted to explore its causes in terms of demographic factors, psychopathological conditions, psychosocial and family environment, and cognitive functions (Aboujaoude, Koran, Gamel, Large, & Serpe, 2006; Ha et al., 2006; Park et al., 2011; Tsai et al., 2009; Wang & Wang, 2013).

In general, individual factors related to online gaming addiction such as sex and age have been considered in previous studies. Most studies report that the male sex conveys a 2–3 times higher risk for internet addiction than the female sex (Lee, Han, Kim, & Renshaw, 2013; Sasmaz et al., 2014). In addition, older age has been reported to be a risk factor for internet addiction among adolescents (Ahmadi & Saghaifi, 2013).

In terms of causal cognitive factors for online gaming addiction, IQ and cognitive flexibility have been considered. A study by Park et al. (2011) noted that adolescents with internet addiction have lower comprehensive sub-item scores on the Wechsler Adult Intelligence Scale (WAIS-R) in comparison to healthy control subjects. A study by Zhou, Yuan, and Yao (2012) indicated that patients with online gaming addiction demonstrate low mental flexibility and response inhibition in modified versions of go/no-go tests. In our previous study, patients with online gaming addiction showed increased numbers of perseverative responses and perseverative errors on the Wisconsin Card Sorting Test (Han, Lyoo, & Renshaw, 2012).

Psychopathological conditions that are often co-morbid with online gaming addiction, attention deficit and hyperactivity

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disorder (ADHD), major depressive disorder (MDD), anxiety, and impulsivity have been considered. Several previous studies of internet addiction have noted that some symptoms in patients with problematic internet use are the same as those observed in other psychopathologies (Aboujaoude et al., 2006). For example, ADHD and MDD are the most frequent comorbid disorders in a South Korean sample population, and the clinical characteristics of internet addiction are similar to clinical symptoms in patients with ADHD or MDD (Ha et al., 2006; Park, Lee, Kim, Jeong, & Han, 2013; Yoo et al., 2004). In a survey of 987 Indian adolescents (Goel, Subramanyam, & Kamath, 2013), adolescents with higher internet addiction score also show higher scores on anxiety and depression scales. The association between violent games and aggressive behavior is controversial. The association between violent games and aggressive behavior is controversial. Past study suggested the correlation between violent video game and aggressive behavior in healthy subjects (Anderson & Dill, 2000). However, a recent time series analysis and meta-analysis have shown that violent films are negatively correlated with aggressive behaviors (Markey, French, & Markey, in press), and there is no evidence that violent video games increase aggression in children (Ferguson, in press).

In terms of social interaction factors that have been related to online gaming addiction, family environment, social anxiety, and self-esteem have been considered. Based on an online survey of 1642 people (19–60 years of age), Wang and Wang (2013) reported that excessive internet use is motivated by cyberspace social encounters in individuals with poor offline social support, including support from family members. However, based on a survey of 2348 college students, Yen et al. (2012) suggested that the internet is a good alternative outlet for individuals with social anxiety. In contrast, Lee and Stapinski (2012) reported that online communication exacerbates face-to-face avoidance in individuals with higher levels of perceived social anxiety.

Self-esteem is thought to mediate social interactions and preference for online social interactions (Caplan, 2005; Fioravanti, Dettore, & Casale, 2012; Stinson et al., 2008). Bozoglan, Demirel, and Sahin (2013) found that low self-esteem was associated with internet addiction in a sample of Turkish university students 18–24 years of age. A study by Lemenager et al. (2013) reported self-confidence deficits in individuals characterized as major users of multiplayer online role-playing games.

Each of these studies, however, focused on only one or two independent factors, without considering the hierarchical importance among variable risk factors. As observed in other addiction disorders as well as in child and adolescent disorders (Lee et al., 2013), identifying the hierarchical importance of risk factors for online gaming addiction may influence policy and treatment. Based on patients with online gaming addiction consecutively referred to the Online Game Clinic Center at OO University Hospital, we aimed to assess the hierarchical importance among individual factors, cognitive functions, psychopathological conditions, and levels of psychosocial and family support in patients with online gaming addiction.

2. Method

2.1. Participants

The current study screened 308 patients with problematic online gaming habits (296 males (96%) and 12 females (4%)), age: mean = 21.0 ± 5.9 years, range: 12–45 years) who visited the Online Game Clinic Center at OO University Hospital from June 2011 to March 2013. Through advertisements posted at OO University and OO University Medical Center, 153 healthy comparison subjects (118 males (77%) and 35 females (23%)), age:

21.2 ± 5.5 years, range: 13–40 years) were recruited to voluntarily participate in the study. Both the patients and the control subjects were screened with the Structured Clinical Interview for DSM-IV (Ha et al., 2006; Kusumakar, MacMaster, Gates, Sparkes, & Khan, 2001), and patients were secondarily diagnosed with comorbidities by two child and adolescent psychiatrists. All subjects were asked to complete questionnaires regarding the severity of internet addiction, individual factors, family environment, social interactions, and comorbidities.

The criteria for online game addiction in the current study were similar to those employed in other previous studies (Han, Hwang, & Renshaw, 2010; Ko et al., 2009). Factors associated with addiction included: (1) online game playing through the internet, more than 4 h per day or 30 h per week, (2) Internet Addiction Scale score >50 (Young, 1996), (3) irritable, anxious, and aggressive behaviors when compelled to stop online game playing, (4) impaired behaviors or distress, economic problems, or maladaptive patterns of regular life due to excessive online game play, and (5) irregular life patterns due to disrupted diurnal rhythms (e.g., sleeping during the day and gaming at night, irregular meals, and failure to maintain personal hygiene), school truancy, or loss of job.

Exclusion criteria included: (1) a history or current episode of other Axis I psychiatric diseases, with the exception of MDD and ADHD, (2) IQ < 80, (3) substance abuse history, with the exception of alcohol or tobacco abuse, and (4) neurological or medical disorder. Ultimately, 263 patients with online gaming addiction (255 males (97%) and 8 females (3%)), age: mean = 20.4 ± 5.8 years, range: 12–45 years), consisting of 109 with only online gaming addiction (referred to herein as pure online gaming addiction), 92 with online gaming addiction and ADHD, and 62 with online gaming addiction and MDD, were included in the study. The patients excluded were 14 patients with multiple diagnoses of online gaming addiction plus ADHD and major depression, 11 patients with schizophrenia, 5 patients with obsessive-compulsive disorder, 4 patients with alcohol dependence, 7 patients with autism spectrum disorders, and 4 patients with mental retardation. The research protocol for the current study was approved by the OO University Hospital Institutional Review Board. Written informed consent was provided by patients older than 18 years. In adolescents younger than 18 years, written informed consent was provided by parents and adolescents.

2.2. Independent factors

2.2.1. Individual factors

For sex, 'male' was coded as '1' and female was coded as '0.' For age, the chronological age of each patients was recorded.

2.2.2. Cognitive functions

2.2.2.1. Korean-Wechsler Adult Intelligent Scale (K-WAIS). The K-WAIS was used to assess the IQ of each subject (Kim, Yum, Oh, Park, & Lee, 1992). The standardized WAIS is the most widely used intelligence test. The K-WAIS-IV is designed for persons 16–69 years of age and is the latest revision, comprising 10 subtests and a composite score. The internal consistency of the K-WAIS has been reported to range from 0.78 to 0.94 (Kim et al., 1992).

2.2.2.2. Wisconsin card sorting test. A computerized version of the Wisconsin Card Sorting Test was used to assess executive function, including set shifting, working memory, and inhibitory control processes in all subjects (CNT4.0, Maxmedica Inc.) (Lee, Shin, Lee, & Lee, 2002). The reliability of the test has been reported to have a Cronbach's α of 0.783 (Lee et al., 2002). The WCST sub-item to evaluate perseverative errors, represented by set shifting, is thought to be associated with prefrontal cortex function (Pedersen et al., 2012). Perseverative errors occur when subjects

do not follow feedback about “correct” and “incorrect” rules but rather continue to act according to the previously correct rules (Heaton, Chelune, Talley, Kay, & Curtiss, 1993).

2.2.3. Psychopathological and psychological conditions

2.2.3.1. Dupaul's ADHD scale – Korean version (K-ARS). The ARS is an ADHD symptom severity scale composed of 18 items (9 items for assessing inattention and 9 items for assessing hyperactivity), designed by Dupaul (1991). The Korean version of the ARS has been validated by So, Noh, Kim, Ko, and Koh (2002). The internal consistency of the K-ARS has been reported to range from 0.77 to 0.89 (So et al., 2002).

2.2.3.2. Beck depressive inventory (BDI). The depression symptom severity scale is composed of 21 items (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). Each question is scored on a scale of 0–3, and the total scores of the BDI range from 0 to 63 points. The Korean version of the BDI was validated by Rhee et al. (1995). Internal consistency of the BDI has been reported to range from 0.75 to 0.85 (Rhee et al., 1995).

2.2.3.3. Beck anxiety scale (BAI). The anxiety symptom severity scale is composed of 21 items (Beck, Epstein, Brown, & Steer, 1988). The BAI was designed as an inventory for measuring clinical anxiety that minimizes the overlap between depression and anxiety scales in particular. The BAI is scored on a scale of 0 to 3 and has a maximum score of 63. The Korean version of the BAI has been validated by Kwon (1997). The internal consistency of the BAI-Korean version is Cronbach's $\alpha = 0.93$ (Kwon, 1997).

2.2.3.4. Behavioral inhibitory system (BIS)/behavioral activation system (BAS) scale. The BIS/BAS is a self-report scale used to assess impulsiveness. Carver and White (1994) developed the BIS/BAS scale to measure differences in BIS and BAS sensitivities of stable individuals. Specially, the BAS is comprised of reward responsiveness (RR), drive, and fun seeking (FS). The Korean version of the BIS/BAS has been validated by Kim and Kim (2001). The BIS/BAS is composed of a 4-point Likert scale ranging from “not at all” to “strongly agree,” and the total scores of BIS/BAS range from 0 to 80. Internal consistency (Cronbach's α) of the BIS/BAS has been reported to range from 0.78 to 0.79 (Kim & Kim, 2001).

2.2.4. Social interaction status

2.2.4.1. Family environment scale (FES). The FES was developed to estimate the social-environmental characteristics of families using 90 items in three sub-domains (i.e., relationships, personal growth, and system maintenance) (Moos & Mood, 2002). Of the three sub-domains, the relationship domain, consisting of three subscales of conflict, expressiveness, and family cohesion, was used to assess family relationships among patients (Moos & Mood, 2002). The test–retest reliability of the Korean version scale ranges from 0.68 to 0.86 (So et al., 2002).

2.2.4.2. Social avoidance and distress scale (SADS). The SADS is a scale to assess the severity of social anxiety and avoidance tendencies and consists of 28 self-reported questions (Watson & Friend, 1969). Two aspects of anxiety are measured, namely, the fear of negative evaluation by others and the tendency to avoid social situations due to distress in the presence of others. Each question is scored on a scale value of 1–5, and the total scores of SADS range from 28 to 140 points. The test–retest reliability of the SADS-Korean version is 0.68 (Lee & Choi, 1997).

2.2.4.3. Two-factor self-esteem scale – Korean (S.E. Scale-Korean). The S.E. Scale-Korean is a self-esteem assessment scale based on a modified version of the Rosenberg Self-Esteem Scale (Rosenberg,

1965). The Rosenberg Self-Esteem Scale consists of 10 statements assessing general feelings toward oneself. Participants are asked to report grades of agreement on a 4-point Likert scale (ranging from 1 = agree not at all to 4 = agree completely). Rosenberg defined self-esteem as an individual's sense of worthiness, which integrates self-respect and self-confidence. The internal consistency of the S.E. Scale-Korean is Cronbach's $\alpha = 0.79$ (Han & Chung, 2007).

2.3. Dependent variable

The single dependent variable of this study, online gaming addiction, was operationalized as a binary code (1/0). If a subject satisfied all five inclusion criteria for online gaming addiction, he or she was coded as 1, otherwise as 0.

2.4. Data analysis

The demographic characteristics of all the patients and the healthy comparison subjects were analyzed with independent t-tests and Chi-square tests. Using multiple logistic regressions in all patients and healthy comparison subjects, the current study added a discrete set of hierarchical variables. In the first stage, individual factors (sex and age) were entered into Model 1 to be correlated with online gaming addiction. Two cognitive factors (IQ and perseverative errors) were entered in the second stage. In the third stage, four psychopathological conditions (ADHD, depression, anxiety, and impulsivity) were added. Finally, three social interaction factors (family environment scale, social anxiety scale, and self-esteem scale) were added. In the group of patients with pure online gaming addiction (i.e., online gaming addiction without comorbidities), a hierarchical logistic regression was applied in the same manner.

The overall fit of each logistic regression model was assessed by using its Chi-square (model Chi-square and step Chi-square) as well as goodness-of-fit indices ($-2 \log$ likelihood). Specifically, the model Chi-square and step Chi-square were evaluated to determine the improvement observed in the model with the predictors relative to the constant-only model or the model that preceded the model with predictors. To evaluate the practical usefulness of each model, tables of classification accuracy were also used to determine the relative success of each model correlated with online gaming addiction. In addition to indices of the overall model fit, Nagelkerke's R^2 was evaluated as an approximate estimate of the amount of variance in the dependent variable accounted for by the model. To test whether each individual factor had a significant relationship with online gaming addiction, Wald statistics were used. When a significant relationship was detected by the Wald test, interpretation of the coefficient was followed by determination of the odds ratio, i.e., the ratio between the probability that the event (i.e., online gaming addiction) would occur to the probability that it would not.

3. Results

There were significant differences in sex, self-esteem, impulsiveness, ADHD, depression, anxiety, family environment scale score, social anxiety scale score, and perseverative errors between the patients with online gaming addiction (PGA) and healthy comparison subjects (Table 1). However, there was no significant difference in age or IQ between PGA and healthy comparison subjects. The average time of online game play in the PGA group was 5.9 ± 2.5 h/day. The genre of online games played by patients included role-playing games (47.1%), real-time simulation games

Table 1
Demographic characteristics.

	PGA (263)	Healthy Controls (153)	Statistics
Age	20.4 ± 5.8	21.2 ± 5.5	–1.43, 0.16
Sex (male/female)	255/8	118/35	$\chi^2 = 41.1$, $p < 0.01$
IQ	103.8 ± 14.0	103.0 ± 13.1	0.6, 0.58
PE	10.9 ± 5.6	9.0 ± 4.1	3.8, <0.01
BIS/BAS	53.6 ± 8.5	49.3 ± 9.2	4.7, <0.01
K-ARS	14.9 ± 9.6	6.1 ± 5.7	10.4, <0.01
K-BDI	14.1 ± 7.5	6.6 ± 5.6	10.6, <0.01
K-BAI	8.6 ± 6.5	4.8 ± 4.8	6.4, <0.01
FES	10.9 ± 5.1	15.7 ± 4.1	–0.8, <0.01
SADS	79.5 ± 14.1	72.4 ± 11.9	5.2, <0.01
S.E.	30.6 ± 8.0	34.3 ± 6.4	–4.9, <0.01
YIAS	63.6 ± 11.5	27.4 ± 8.2	34.2, <0.01
Game Time (hour/day)	5.9 ± 2.5		
Game Genre			
RPG	124 (47.1%)		
RTS	79 (30.0%)		
FPS	36 (13.7%)		
Other	24 (9.1%)		

PGA: Patients with online game addiction, IQ: intelligence quotient, PE: perseverative error, BIS/BAS: Behavioral inhibitory system/behavioral activation system scale scores, K-ARS: Dupaul's ADHD scale – Korean version, K-BDI: Beck Depressive Inventory Korean version, K-BAI: Beck Anxiety Scale Korean version, FES: Family environment scale, SADS: Social avoidance and distress scale, S.E.: Two-factor self-esteem scale – Korean version, YIAS: Internet Addiction Scale Scores, RPG: role-playing game, RTS: real-time simulation, FPS: first-person shooting games, Other: genres including sports, arcade games, board games, etc.

(30.0%), first-person shooting games (13.7%), and other games (9.1%).

3.1. Risk factors for online gaming addiction in all patients

All four models (individual factors, cognitive factors, psychopathological conditions, and social interaction factors) were significantly associated with online gaming addiction and improved the overall model fit in all patients. With the highest step Chi-square value and improvement in classification accuracy, psychopathological conditions were the strongest risk factors for online gaming addiction in comparison to the three other sets of factors. Model 1 (two demographic factors of sex and age) significantly predicted online gaming addiction with 69.7% prediction accuracy. Model 2 significantly enhanced the predictability of online gaming addiction in comparison to the null model and Model 1, with 69.2% prediction accuracy. Model 3 (Model 2 + four psychopathological conditions of ADHD, depression, anxiety, and impulsiveness) significantly enhanced the predictability of online gaming addiction in comparison to the null model and Model 2, with 82.9% prediction accuracy. Model 4 (Model 3 + three social interaction factors of family environment, social avoidance, and self-esteem) significantly enhanced the predictability of online gaming addiction in comparison to the null model and Model 3, with 85.8% prediction accuracy (Table 2). According to the Wald statistics for all independent variables, the variables of sex, perseverative errors (PE), K-ARS, K-BDI, and self-esteem were significant predictors of online gaming addiction (Table 3).

Table 2
Summary statistics of Model 1.

Variables	All patients					Pure online game addiction				
	B	S.E.	Wald	Sig.	O.R.	B	S.E.	Wald	Sig.	O.R.
Sex	2.224	0.408	29.700	<0.001	9.245	2.099	0.547	14.703	<0.001	8.160
Age	–0.018	0.019	0.896	0.344	0.982	–0.028	0.023	1.440	0.230	0.973
Indices	Null model		Model 1			Null model		Model 1		
–2LL	547.3		505.5			355.8		330.0		
Model χ^2	N/A		41.3			N/A		23.1		
Nag R^2	N/A		0.129			N/A		0.113		
Class accur	63.2		69.7			58.4		63.0		

–2LL: –2 log likelihood, Nag R^2 : Nagelkerke's R^2 , Class accur: classification accuracy, dependent factor: online game addiction, Model 1: individual factors (sex and age).

Table 3
Summary statistics of Model 2.

Variables	All patients					Pure online game addiction				
	B	S.E.	Wald	Sig.	O.R.	B	S.E.	Wald	Sig.	O.R.
Sex	2.147	0.408	26.700	<0.001	8.563	2.030	0.550	13.613	<0.001	7.612
Age	–0.017	0.019	0.740	0.390	0.983	–0.025	0.023	1.140	0.286	0.975
IQ	0.004	0.008	0.199	0.656	1.004	–0.006	0.010	0.391	0.532	0.994
PE	0.084	0.026	10.582	0.001	1.088	–0.046	0.031	2.251	0.134	0.955
Indices	Null model		Model 1			Null model		Model 1		
–2LL	547.3		493.8			355.8		277.4		
			505.5					330.0		
Model χ^2	N/A		53.5			N/A		25.8		
			41.3					23.1		
Nag R^2	N/A		0.165			N/A		0.126		
			0.129					0.113		
Class accur	63.2		69.2			58.4		62.6		
			69.7					63.0		

–2LL: –2 log likelihood, Nag R^2 : Nagelkerke's R^2 , Class accur: classification accuracy, dependent factor: online game addiction, Model 1: individual factors (sex and age), Model 2: cognitive factors intelligence quotient (IQ and perseverative errors (PE)).

Table 4
Summary statistics of Model 3.

Variables	All patients					Pure online game addiction				
	B	S.E.	Wald	Sig	O.R.	B	S.E.	Wald	Sig	O.R.
Sex	2.346	0.540	18.898	<0.001	10.440	2.596	0.667	15.130	<0.001	13.406
Age	0.016	0.026	0.387	0.534	1.016	−0.040	0.026	2.353	0.125	0.961
IQ	0.012	0.010	1.281	0.258	1.012	−0.011	0.011	1.030	0.310	0.989
PE	0.077	0.030	6.398	0.011	1.080	−0.059	0.033	3.176	0.075	0.943
BIS/BAS	0.012	0.017	0.496	0.481	1.012	−0.012	0.017	0.492	0.483	0.988
K-ARS	0.129	0.023	32.531	<0.001	1.137	−0.081	0.028	8.453	0.004	0.922
K-BDI	0.128	0.025	26.703	<0.001	1.136	−0.079	0.028	7.620	0.006	0.924
BAI	0.034	0.034	0.990	0.320	1.035	−0.037	0.036	1.089	0.297	0.964
Indices	Null model	Model 1	Model 2	Model 3		Null model	Model 1	Model 2	Model 3	
−2LL	547.3	505.5	493.8	337.2		355.8	330.0	277.4	281.5	
Model χ^2	N/A	41.3	53.5	210.1		N/A	23.1	25.8	74.2	
Nag R^2	N/A	0.129	0.165	0.542		N/A	0.113	0.126	0.332	
Class accur	63.2	69.7	69.2	82.9		58.4	63.0	62.6	75.6	

−2LL: −2 log likelihood, Nag R^2 : Nagelkerke's R^2 , Class accur: classification accuracy, dependent factor: online game addiction, Model 1: individual factors (sex and age), Model 2: cognitive factors intelligence quotient (IQ and perseverative errors (PE)), Model 3: four psychopathological conditions (attention deficit hyperactivity disorder (ADHD) rating scale (K-ARS), Beck Depressive Inventory (BDI), Beck Anxiety Inventory (BAI), and Barrette Impulse Scale (BIS/BAS)).

Table 5
Summary statistics of Model 4.

Variables	All patients					Pure online game addiction				
	B	S.E.	Wald	Sig	O.R.	B	S.E.	Wald	Sig	O.R.
Sex	2.455	0.578	18.029	<0.001	11.643	2.541	0.692	13.478	<0.001	12.687
Age	0.047	0.028	2.860	0.091	1.048	−0.067	0.029	5.496	0.019	0.935
IQ	0.013	0.011	1.337	0.248	1.013	−0.012	0.011	1.186	0.276	0.958
PE	0.082	0.034	5.881	0.015	1.085	−0.065	0.037	3.125	0.077	0.937
BIS/BAS	0.015	0.017	0.715	0.398	1.015	−0.014	0.018	0.546	0.460	0.986
K-ARS	0.119	0.024	25.026	<0.001	1.127	−0.069	0.029	5.576	0.018	0.933
K-BDI	0.097	0.027	13.498	<0.001	1.102	−0.068	0.030	5.167	0.023	0.934
BAI	0.025	0.036	0.486	0.486	1.025	−0.029	0.037	0.629	0.428	0.971
FES	−0.134	0.033	16.398	<0.001	0.875	0.117	0.036	0.629	10.284	0.001
SADS	0.018	0.011	2.498	0.114	1.018	−0.015	0.013	1.330	0.249	0.985
S.E.	−0.048	0.021	5.313	0.021	0.953	0.052	0.024	4.676	0.031	1.053
Indices	Null model	Model 1	Model 2	Model 3	Model 4	Null model	Model 1	Model 2	Model 3	Model 4
−2LL	547.3	505.5	493.8	337.2	304.0	355.8	330.0	277.4	281.5	258.7
Model χ^2	N/A	41.3	53.5	210.1	243.2	N/A	23.1	25.8	74.2	97.1
Nag R^2	N/A	0.129	0.165	0.542	0.605	N/A	0.113	0.126	0.332	0.417
Class accur	63.2	69.7	69.2	82.9	85.8	58.4	63.0	62.6	75.6	78.6

−2LL: −2 log likelihood, Nag R^2 : Nagelkerke's R^2 , Class accur: classification accuracy, dependent factor: online game addiction, Model 1: individual factors (sex and age), Model 2: cognitive factors intelligence quotient (IQ and perseverative errors (PE)), Model 3: four psychopathological conditions (attention deficit hyperactivity disorder (ADHD) rating scale (K-ARS), Beck Depressive Inventory (BDI), Beck Anxiety Inventory (BAI), and Barrette Impulse Scale (BIS/BAS)), Model 4: social interaction factors (family environmental scale (FES), social anxiety scale (SADS), and self esteem scale (S.E.)).

3.2. Risk factors for online gaming addiction in patients with pure online gaming addiction

Three of the tested models (individual factors, psychological conditions, and social interaction factors), with the exception of Model 2 (cognitive factors), were significantly associated with online gaming addiction and improved the overall model fit in patients with pure online gaming addiction. With the evidence of the highest step Chi-square value and improvement in classification accuracy, psychological conditions were the strongest set of factors predicting online gaming addiction. Model 1 (two individual factors of sex and age) significantly predicted online gaming addiction with 63% prediction accuracy. Model 2 (Model 1 + two cognitive factors of IQ and perseverative errors) significantly enhanced the association of online gaming addiction in comparison to the null model and Model 1. Model 3 (Model 2 + four psychological conditions of ADHD, depression, anxiety, and impulsiveness) significantly enhanced the association of online gaming addiction in comparison to the null model and Model 2, with 75.6% prediction accuracy. Model 4 (Model 3 + three social

interaction factors of family environment, social avoidance, and self esteem) significantly enhanced the association of online gaming addiction in comparison to the null model, with 78.6% prediction accuracy. Cognitive factors, however, failed to show a statistical improvement of the overall model fit against Model 3 in patients with pure online gaming addiction (Table 4). According to the Wald statistics for all independent variables, the variables of sex, age, K-ARS, K-BDI, FES, and self-esteem were significantly associated with online gaming addiction (Table 5). In checking multicollinearity among 11 independent variables, the range of tolerance value was from 0.579 to 0.993 and the range of variance inflation factor (VIF) was from 1.007 to 1.728.

4. Discussion

Of the four risk categories including individual factors, cognitive functions, psychopathologies, and social interactions, psychopathologies were the strongest risk factors for online gaming addiction in all patients. Specifically, sex, self-esteem, attention, depressive moods, family environment, and perseverative errors

were significantly associated with online gaming addiction. In patients with pure online gaming addiction, associations were found with individual factors, psychological factors, and social interactions. Of the four categories, psychopathologies were the strongest risk factors for online gaming addiction in patients with pure online gaming addiction. Specifically, sex, age, self-esteem, attention, depressive moods, and family environment were significantly associated with online gaming addiction in these patients.

4.1. Individual factors

Of the two individual factors, sex was a risk factor for online gaming addiction in all patients. Both sex and age were also associated with online gaming addiction in patients with pure online gaming addiction.

Sex differences may be due to different online use between males and females. Female adolescents typically use online networking for enhancing communication and sharing information via instant messaging, chatting, and visiting personal websites. However, male adolescents mainly use online networking for playing online games (Gross, 2004). In addition, temperamental characteristics, including higher levels of novelty seeking, higher comorbidity of ADHD, and higher levels of impulsivity in males are responsible for higher rates of online gaming addiction relative to females (Bozkurt, Coskun, Ayaydin, Adak, & Zoroglu, 2013; Dalbudak et al., 2013; Ko et al., 2010; Wu et al., 2013). A study by Park et al. (2013) reports that increased age is a risk factor for online gaming addiction in adolescent patients.

4.2. Cognitive factors

Although there are controversies in terms of the relation between cognitive function and internet addiction, the results of the current study suggest that perseverative errors but not IQ are associated with online gaming addiction. Disrupted perseverative responses have been reported in patients with internet addiction (Han, Kim, Lee, & Renshaw, 2012; Han, Lyoo et al., 2012; Zhou et al., 2012). Relative to healthy comparison subjects, patients with online gaming addiction tend to show increased numbers of perseverative errors (Kusumakar et al., 2001). Poor executive functioning, including low mental flexibility and response inhibition in patients with online gaming addiction, are thought to be associated with the severity of the addiction (Lemenager et al., 2013). A study by Park et al. (2011) reported that lower comprehensive sub-item scores of WAIS-R were associated with internet addiction. The results of the current study, however, did not show any correlation between IQ and online gaming addiction. The difference between the findings of Park et al. and the current research may be due to the number of subjects, the consideration of comorbidities, or the interactions between other risk factors.

4.3. Psychopathological factors

Psychopathologies, especially ADHD and MDD, were the strongest risk factors for online gaming addiction in the current study. In a systematic review of 20 articles about comorbid psychopathologies and pathological internet use, Carli et al. (2013) reported that 100% of articles claim that pathological internet use is associated with symptoms of ADHD, and 75% of the articles assert that pathological internet use is associated with MDD. According to a survey of 2793 college students, adult ADHD is also associated with internet addiction (Yen, Yen, Chen, Tang, & Ko, 2009). The strong association between pathological internet use and ADHD may be related to the characteristics of ADHD, insofar as both sets of patients tend to be easily bored and thrive on instant gratification (Campbell & von Stauffenberg, 2009; Carli et al., 2013). Moreover,

Fergusson and Ceranoglu suggest that pathologic gaming behavior may be a symptom of underlying ADHD rather than a unique disease (Fergusson and Ceranoglu, 2014). In our group of patients with pure online gaming addiction (i.e., patients without comorbid ADHD or MDD), K-ARS scores and K-BDI scores were also associated with online gaming addiction. In German game players, emotionally sensitive users play online games more for the purpose of interaction with friends, compared to less sensitive users (Kowert et al., 2014). These results suggest that online gaming addiction may be aggravated by sub-clinical ADHD and MDD. Although there were significant differences between the online gaming addiction group and the healthy comparison group in the present study, the characteristic of impulsiveness, as assessed via the BIS/BAS scale, was not associated with online gaming addiction. Many studies suggest that a high level of impulsiveness is associated with internet addiction (Bozkurt et al., 2013; Wu et al., 2013). One group has suggested that internet addiction should be classified as an impulse control disorder (Dell'Osso et al., 2008). The divergent results of the current research from previous research may be due to interaction effects among the K-ARS and K-BDI scores.

4.4. Social interaction factors

The results of the current research show that the factor of family environment within the set of social interaction factors is an important risk factor for an online gaming addiction. Tsai et al. (2009) demonstrated that offline social support and interaction with family and colleagues in a study of 1360 university freshmen negatively correlated with internet addiction. In a study of family factors contributing to internet addiction, Yen, Yen, Chen, Chen, and Ko (2007) reported that a higher level of conflict between parents and children together with a lower level of family cohesion is a risk factor for internet addiction. A study by Han, Kim et al. (2012), Han, Lyoo et al. (2012) reported that a three-week period of intensive family intervention improved the severity of online game addiction and increased the activity of the caudate nucleus in response to the affect scene. The present study also found that family environment factors were associated with online gaming addiction. Although there were no significant results between social anxiety and online gaming addiction in the present study, social anxiety should be considered to be associated with online gaming addiction. Our result may have been due to the control of psychological factors (BAI score) in the previous analysis steps. A study by Rusconi et al. (2012) reported that increased anxiety due to social interaction is associated with prolonged use of the internet and social network services. A robust level of self-esteem is known to be a protective factor against drug and alcohol addiction, as well as internet addiction. Decreased levels of self-esteem have also been reported to be associated with internet addiction and online gaming addiction (Bozoglan et al., 2013; Lemenager et al., 2013). Practical support together with positive role models for patients with drug or alcohol addiction could lead to successful recovery from such an addiction due to increased self-esteem (Johansen, Brendryen, Darnell, & Wennesland, 2013). Future studies should consider additional factors that can affect online gaming addiction including the type of gaming (offline, computer, console, apps, etc.), game genre, and other addiction comorbidities.

5. Limitations

There are several limitations to the current results. First, although we determined the statistical design in light of previous studies, the arbitrary classification of independent factors and the arbitrary inclusion criteria of 'online gaming addiction' may reduce

the reliability for factors predicting online gaming addiction. In particular, the time spent gaming as an inclusion criterion for online gaming addiction is controversial (Charlton & Danforth, 2007; Skoric, Lay Ching Teo, & Lijie Neo, 2009). Second, the current study did not consider the use of other online facilities such as smart phone services, internet chatting, or smart television. Third, there was a very low percentage of females in the current study; thus, the generalizability of the results to online gaming addiction in females is limited. Third, because game preference and prevalence of ADHD are associated with males, the effect sizes of risk factors other than sex in the regression analysis might have been small. Readers should consider these limitations when interpreting the results.

6. Conclusion

The current study assessed the hierarchical importance of four sets of risk factors for online gaming addiction. These factor sets included individual factors, cognitive functions, psychopathologies, and social interactions in patients with online gaming addiction. Psychopathologies including ADHD and depression were the strongest risk factors for the addiction. Control and treatment of ADHD and major depressive disorder may be important for the prevention of online game addiction. Additionally, family environment and self-esteem within the set of social interaction factors were important risk factors for online game addiction.

Conflicts of interest

The authors declare that they have no conflict of interest.

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