Treatment Efficacy of Internet Gaming Disorder with Attention Deficit Hyperactivity Disorder and Emotional Dysregulation

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Abstract

Aims: Recent youth with Attention Deficit Hyperactivity Disorder (ADHD) noticed emotional dysregulation if they had Internet Gaming Disorder (IGD). This study aims to understand the treatment efficacy of Internet Gaming Disorder with Attention Deficit Hyperactivity Disorder and Emotional Dysregulation. Method: 101 ADHD youths were recruited. We used Chen Internet Addiction Scale (CIAS) and IGD criteria of DSM-5 to confirm IGD. The Swanson, Nolan, and Pelham, questionnaire Version IV (SNAP-IV) was used for symptoms of ADHD and oppositional defiant disorder (ODD). Disruptive mood Dysregulation Disorder was assessed by psychiatrist. Result: There is a new phenomenon that emotional dysregulation frequently noticed on severely gaming addicted ADHD youth. Treatment efficacy of IGD is good when the underlying symptom of ADHD is controlled. Symptom scores of DMDD were significantly reduced by 71.9%, 74.8%, and 84.4% at week 2, 3, and 4, respectively (p ≤ 0.001) after adjusting baseline symptom severity. Conclusion: Internet Gaming Disorder may strongly arouse emotional dysregulation. Future DSM criteria could consider these gaming addicted youth as a specific sub-class of ADHD.

Key words: ADHD, IGD, treatment efficacy, DMDD
Significance Statement

The number of youth with internet addiction is gradually increasing. Everyone starts to notice the adverse influence of the internet gaming disorder toward children and adolescents. The children and adolescent psychiatrist definitely highlight the lethal influence of self-injury, suicide, or comorbidity of gaming disorder. But no one has ever suggested the lethality of emotional dysregulation in the development of children. Clinically, we first noticed that Internet gaming disorder can cause disruptive mood dysregulation on children. Therefore, we must face this new adverse effects of Internet gaming disorder on children's growing days. Especially for those child and adolescent with attention deficit hyperactivity disorder (ADHD), they need earlier recognition and treatment of disruptive mood dysregulation disorder like symptom.
Introduction

Majority of the modern youth played with computers for pleasure and spends excessive time on computer gaming or social media (Sriwilai and Charoensukmongkol, 2016). The internet brought great convenience or benefit to people. Although some studies denied a concrete evidence of an association between pathologic internet overusing and psychiatric disorders (Przybylski et al., 2017), the complicated negative mood indeed noticed or speeded on child and adolescent populations, while they were falling into an internet-addicted state (Jorgenson et al., 2016). The reported serious consequences of internet gaming disorder (IGD) including cyber-bullying (Gamez-Guadix et al., 2016), disorganized behavior and compromised self-care (Sachdeva and Verma, 2015), unhealthy life and high risk behavior(Durkee et al., 2016), internet criminality (Recupero, 2008), social aggression or self-aggression (Bayraktar and Gun, 2007), and social withdrawal state or so called “Hikikomori syndrome” (Stip et al., 2016).

Only because youth with IGD ultimately became increasingly aggressive, violent, or delinquent (Weissenberger et al., 2016), American Psychiatric Association (APA) recently included IGD as a supplementary diagnosis in the new DSM-5 criteria (Reinhardt and Reinhardt, 2013; Yen et al., 2007; Yoo et al., 2004). Child mental health experts had started to notice many hazards caused by internet addiction (Nakayama et al., 2017) and focused more on treatment efficacy of IGD among clinical sample.

Despite many previous studies reported IGD comorbid with various mental disorder, (Young, 2008) depression and anxiety, higher degrees of impulsiveness and anger/aggression, higher levels of distress, poorer quality of life, and impaired inhibition response, (Lim et al., 2016) the research on treatment efficacy of IGD among clinical sample is few. As we mention the treatment efficacy of IGD, the treatment effect of clinically comorbid other mental disorder of IGD should be explored appropriately. Clinically, the Attention deficit hyperactivity disorder (ADHD) mostly co-occurred with IGD among child and adolescent population (Bozkurt et al., 2013) also shown by the meta-analysis
study conducted by Ho et al. (Ho et al., 2014). Therefore, the treatment efficacy of IGD should consider the treatment efficacy of underlying ADHD and other mental disorder.

Another new interesting mental consequence of gaming addiction is their severe irritability or emotional disruption toward their caregiver (Kaptsis et al., 2016). It might be imaginable when the parents forced their children to quit it, majority of youth experienced withdrawal syndrome of internet addiction presented as emotional disruption. Although one recent study indicated childhood emotion regulation deficits can predict symptoms of IGD on age 10 years (Wichstrom et al., 2019). Only few reported emotional dysregulation after IGD, not even more the treatment efficacy study toward this IGD with emotional dysregulation before. For youth with ADHD, such disruptive mood is dangerous and worthy an immediate need to explore the association between IGD and disruptive mood. Therefore, ADHD youth’s similar symptom presentation of disruptive mood dysregulation disorder (DMDD) after their withdrawal syndrome of internet addiction should be assessed and also treated earlier.

As reviewing the literature on the treatment efficacy of IGD, only the following treatment options were summarized: Pharmacotherapy by methylphenidate (MPH) and Atomoxetine (ATM) both can reduce the symptom severity of children with IGD comorbid with ADHD. (Park et al., 2016) Furthermore, Han et al. in Korea highlighted that MPH might play significant role as a potential treatment drug for internet addiction. (Han et al., 2009) Antidepressants such as bupropion and Escitalopram were also found to be effective in treating symptom of IGD comorbid with depressive symptom (Song et al., 2016). Otherwise, providing non-pharmacological intervention as cognitive behavioral therapy and family therapy to patient and their parent is also very important and effective treatment of IGD (Elsalhy et al., 2016). Treatment efficacy of IGD depends on how well the symptoms of ADHD (Chou et al., 2015), the symptom severity of ADHD (Dalbudak and Evren, 2014) being controlled. But there is not study before to explored treatment effect of IGD with ADHD and DMDD like symptom.
This study used the clinical patient data from out-patient department (OPD) of psychiatry to study the proportion of emotional dysregulation presented as DMDD like symptom and to understand the treatment efficacy among gaming addicted ADHD youth. Here we hypothesized the impulsive or disruptive mood dysregulation may lead treatment efficacy of IGD become poor. Moreover, we need to explore whether only controlling symptom of ADHD still would be also effective for the children co-occurring with ADHD, IGD, and DMDD. Results of this study may provide guidelines to child psychiatrists for diagnosing IGD earlier and treating them early with consideration of the linkage from ADHD to IGD with emotional dysregulation in the current modern society.

Method

Participants and data collection

Patients were recruited from the Out-Patient Units of Mackay Memorial Hospital (MMH) in Taipei, Taiwan. The research protocol was approved by the MMH Institutional Review Boards (IRB). Written informed consent was obtained from each subject in line with the IRB guidelines. The inclusion criteria were males or females with ADHD from 7–18 years old. The exclusion criteria were as follows: paediatric patients or their parent(s)/caregiver(s) with known or suspected psychotic disease, mental retardation, or other mental conditions that would prevent them from completing the study. After obtaining a signed consent from a legal guardian, each subject recruited for this study was invited to participate in the following programs and were interviewed to provide the following measurements:
Measurement

Chen Internet Addiction Scale (CIA)

The CIA is a self-reported questionnaire consisting of 26 questions on a four-point scale that assesses with good reliability and validity (Chen et al., 2003) the five dimensions of Internet use-related problems: compulsive use, withdrawal, tolerance, interpersonal and health problems, and time management problems. The internal reliability of the scale and the subscales in the original study ranged from 0.79 to 0.93. Higher CIA scores indicated increased severity of Internet addiction. The CIA has good diagnostic accuracy (89.6%). The screening cut-off point had high sensitivity (85.6%) and the diagnostic cut-off point had the highest diagnostic accuracy, classifying 87.6% of participants correctly.

Swanson, Nolan, and Pelham, Version IV questionnaire (SNAP-IV)

The SNAP-IV consists of the following items: inattention, hyperactivity/impulsivity, and oppositional symptoms. These items reflect the core symptoms of ADHD and Oppositional Defiant Disorder as defined in the DSM-IV. The psychometric properties of SNAP-IV-Chinese in Taiwan showed the intra-class correlation coefficients for the three subscales of the Chinese SNAP-IV ranged from 0.59 to 0.72 for the parent form and from 0.60 to 0.84 for the teacher form. All subscales of both the parent and teacher forms showed excellent internal consistency with Cronbach’s α greater than 0.88 (Liu et al., 2006).

Statistical Analysis

Descriptive statistics were applied to show demographic characteristics. Differences of categorical variables between groups were compared by either chi-square tests or Fisher’s exact tests (whichever is appropriate). Numerical variables were tested by the Student’s t test. All statistical analyses were analysed by using SPSS v22.0 (SPSS Inc., Chicago, IL, USA). Furthermore, to take into account the within subject’s dependency due to repeated measurements, the GEE method’s multiple linear regression and/or logistic regression models were used to compare the
Results:

A total of 101 eligible ADHD children were enrolled in this study. They completed the baseline data of the three aforementioned evaluation forms. The results of the comparison of baseline characteristic of ADHD patients between IA and non-IA groups are shown in Table 1. Among them, there were significant differences in interpersonal relationship, DMDD, comorbidity, daily and/or weekend online chatting or gaming, and age. Other factors of ADHD patients, such as height, weight, father’s age, and mother’s age, were also significantly different (p < 0.05). The scores of IA severity-related scales, DMDD, CIAS, and DSMS were significantly different between these two groups at baseline (p < 0.001).

To compare the treatment effects between IA and non-IA groups, we analyzed the baseline score, group, treatment duration (in week), and their interaction by multiple linear regression using GEE’s method. As shown in Table 2, after adjusting for the effect of baseline severity, the effect of treatment of inattention, hyperactivity/impulsivity, and symptoms of ODD in the non-IA group was significantly reduced (9.370, 6.477, and 2.947 units, respectively) (p < 0.001, < 0.001, and 0.004, respectively). In contrast, the reduction in inattentive symptoms score in the IA groups was 5.269 (= 9.370 - 4.101) units, which was 4.101 units lesser in symptomatic reduction than the non-IA group (p = 0.011). However, in the IA group, the reduction in the other two symptom scores, hyperactivity/impulsivity and ODD, was similar to the non-IA group (p = 0.303 and 0.743, respectively). Similarly, the severity of DMDD (total score) was significantly reduced, on average, 0.595 units in the non-IA group (p=0.006). In the IA group, the reduction of DMDD total score (from
baseline to week 4) was almost similar to that of the non-IA group (p = 0.953), after adjusting for the effect of baseline severity.

The GEE method’s multiple linear regression model was used to compare the differences of the treatment effects between these two groups according to CIAS and DSM-5, given the high correlation between these two scales (Pearson correlation = 0.864 and 0.856 at baseline and week 4, respective). As shown in Table 2, four weeks later, the severity of internet addiction in the non-IA group was slightly increased (1.411 units) on the CIAS scale (p = 0.482). On the other hands, the reduction of the IA severity in the IA group was, on average, 4.540 (= 5.951 - 1.411) units, which was 5.951 units significantly higher than that of the non-IA group (p = 0.031). However, the severity of internet addiction in the DSM-5 scale remained almost the same at baseline and week 4 in both groups.

After four weeks’ treatment, to evaluate the treatment effects on DMDD, we first defined a child to be comorbid with DMDD if his/her symptom scale of DMDD > 0 and then used the GEE method’s multiple logistic regression to analyze the data. As shown in Table 3, compared to the baseline, the odds ratios of the risk of IGD patients comorbid with DMDD were 0.281, 0.252, and 0.156 at week 2, 3, and 4, respectively, with all p-values < 0.001, after adjusting for the effect of baseline severity. In other words, compare to the risk at baseline, the risk (odds) of IGD patients comorbid with DMDD were significantly reduced 71.9%, 74.8%, and 84.4% at week 2, 3, and 4, respectively (p ≤ 0.001), after adjusting for the effect of baseline severity. We further compared the difference of the treatment effects between IA and non-IA groups. As shown in Table 4, after adjusting for the effect of baseline severity, the odds ratio for IGD patients comorbid with DMDD for IA vs. non-IA was 2.528 at baseline (p = 0.020). For the non-IA group, the odds ratio for IGD patients comorbid with DMDD was 0.085 for week 4 vs. baseline (p = 0.021). Moreover, the odds ratio for IGD patients comorbid with DMDD for week 4 vs. baseline in the IA group was 86.0% (=1 - 0.140) less than the odds ratio of the non-IA group, although the result only reached the borderline significance (p = 0.095).
**Discussion:**

From the present study included clinical patients from out-patient department of psychiatry, we found that diagnosis of IGD based on DSM-5 criteria was not low (51.5%) among youth with ADHD. Interestingly, internet addicted ADHD youths were more comorbid with DMDD like emotional dysregulation than ADHD youths without gaming disorder. The complicated irritable mood or emotional dysregulation indeed noticed after internet gaming disorder and we should regard this phenomenon as new complication of ADHD with IGD.

For the internet-addicted youth with ADHD, they were characterized as following: having poor interpersonal relationships, spending the excessive time in online chatting or playing online games for more than one hour per day and more than 3 hours per weekend day. Comparing to the ADHD youth without internet addiction, there was no difference in their genders or in general appearances, but they were 2 years elder in age, having older father and mother, were 10 cm higher, and had 10 kg fatter.

Overall treatment effect of IGD would be good when the underlying symptom of inattention, hyperactivity/impulsivity, and oppositional defiant disorder were controlled by ADHD pharmacotherapy. Such results were in line with a Korean study, which reported that methylphenidate (MPH) was effective in treatment of IGD. (Han et al., 2009; Park et al., 2016) Furthermore, this study indicated that even the internet addicted ADHD youth associated with symptom of DMDD, still psychostimulant-Methylphenidate(MPH), Atomoxetine (Strattera), MPH and Abilify, or Strattera and Ability can be used as a satisfactory choice of drug on treating IGD. The degree of improvement on ADHD and DMDD scales determined the treatment efficacy of IGD. After 4 weeks treatment, the odds ratios of DMDD were significantly reduced (54.2%, 59.1%, and 68.4% at
week 2, 3, and 4, respectively). In summary, treatment effect for IGD comorbid with ADHD and DMDD was good overall.

For a long time, pile of studies demonstrated addicted behavior may induce an emotional dysregulation (Murphy et al., 2012). But how is the process from seeming playful gaming addiction to disruptive mood dysregulation? Here we try to employ presently commonly used Research Domain Criteria (RDoC) dimensions model to explain this nowadays phenomenon why the irritable ADHD child developed as Gaming Disorder with aggression. In the RDoC perspective, ADHD patient also have deficit in domain of Cognition (specifically in Working Memory) and Positive Valence (in rewarding anticipation/delay/receipt)(Musser and Raiker, 2019). The substance use disordered patients exhibit problem on domain of Negative Valence Systems, Positive Valence Systems, Cognitive Systems, Systems for Social Processes, and Arousal and Regulatory Systems (Zambrano-Vazquez et al., 2017). Indeed, Gaming disorder and ADHD has disordered brain function overlapping on domain of Executive function, Incentive Salience, and Negative Emotionality (Kwako et al., 2016). As a result, deficit on domain of Cognitive System, Negative Emotionality is interactively increasing symptom of ADHD and gaming disorder.

Firstly, children with ADHD generally avoid the complicated task because they have somehow executive function impairment. According to the psychopathology explained by RDoC dimensions model, such children’s inattentive symptom closely correlated with symptom of irritability and aggression which representing brain deficit over domain of Negative Affect. In addition, as inattentive ADHD child over involved in internet gaming world, they tend to overplay even habitually play gaming representing the disturbance on the domain of Incentive Salience (Kwako et al., 2016) cause by internet gaming. Intermixed brain disturbance on domain of Negative Affect by ADHD and disturbance on the domain of Incentive Salience by gaming disorder, eventually leading ADHD child develop the symptom of the distorted liking or wanting gaming first. Then, they develop the withdrawal-negative affect as they were stopped to play gaming. Such DMDD like withdrawal...
emotional disturbance representing more disturbed Negative Emotionality domain on RDoC domain model again. From impairment in executive function from ADHD go through disturbance mood dysregulation, and finally progress to the more withdrawal-negative affect on ADHD children, this is a vicious cycle caused by effect of gaming disorder adding on effect of ADHD. IGD play an aggravating coping mechanism for ADHD from this clinical sample. Therefore, it is explainable that gaming disorder may increase the symptom severity of ADHD with more symptom of irritability, and finally they become aggressive, loss of control, craving/withdrawal from addiction in gaming (Lee et al., 2017b). Our study result indicated the ADHD children with irritability and aggression may become more severe disruptive emotional symptoms because symptom of IGD aggravating symptom of ADHD, irritability, and aggression.

Why gaming addicted ADHD youth become emotional dysregulation or transiently presented symptom like DMDD? From these study results, we provide following explanation: gaming disorder is a superficial mental problem outside their unresolved underlying psychiatric mental disorder (Eichenberg et al., 2017). The longer time on playing gaming full of aggressive content may aggravate underlying mental disorder through long process of social interaction deprivation or stimulation deprivation. This can be explained by many studies on aggressive behavior on youth with IGD (Ybarra et al., 2008). IGD is not only a superficial symptom to avoid the social interaction and complicated learning task. Worse side of these gaming addicted ADHD youth with emotional dysregulation is they belong to so-called the subtype of ‘impulsive/aggressive,’ ‘emotionally vulnerable’ of IGD (Lee et al., 2017a). They lived a life with poorer interpersonal relationship or unhealthy lifestyle first, gradually lead ADHD youth to develop unhealthy psychologically disruptive mood dysregulation. Especially, when one day they became gaming addicted with withdrawal symptom, their hiding emotional disruption and impulsive behavior problem burst out. Here we suggested the child mental health experts should consider the internet addiction as a formal diagnosis earlier and start to treat them as early as possible to prevent further disruptive mood dysregulation. Because the consequence of DMDD in child and adolescent is becoming adverse
health outcomes, impoverished, reported police contact, low educational attainment, higher rates of having an official felony charges, physical fighting and breaking into buildings illegally, disrupted social function (violent relationships, poor parental relations, and no best friend) (Copeland et al., 2014).

The internet addiction should become a diagnostic reminder of the possibility of subsequent sequelae like disruptive emotionality (DMDD) in children and adolescent with ADHD. DMDD diagnosis in future DSM diagnosing itself should be noticed on children with IGD frequently appeared opposing resistance, bad temper, and negative emotions.

The limitation of this study was that we had only small sample size from a medical center, so it does not represent the IGD across the whole country. The diagnosis of this additional DMDD is based on DSM-5 diagnosis. We did not differentiate such emotional dysregulation after IGD was appeared usually or only in the withdrawal period. However, after the treatment, the symptom severity of DMDD was relatively reduced. Therefore, the stability of diagnosis of DMDD may be questioned. Thus, DMDD in this study should be expressed as emotional disruptive symptom like diagnosis of DMDD. Indeed, we had a tendency to confuse readers by using DMDD as a construct to express the withdrawal symptom of gaming disorder. In this paper, as there is only psychiatrist’s diagnosis instead of the structured measure for DMDD. Thus, DMDD may not equal to withdrawal emotional dysregulation albeit we attempt to express the symptom severity of withdrawal emotional dysregulation as they were stopped to play gaming. Also irritable symptom is chief symptom of ODD, irritable symptom in DMDD symptom may overlap with irritable symptom of ODD (Meyers et al., 2017). So DMDD and irritability-mood deregulation-aggression are used interchangeably here. Taken together, this is valuable information as clinicians struggle to understand the irritability and potential aggression that families experience when interrupting the behaviors. This symptom complex often interferes with the parent’s ability to alter the gaming behaviors. Pharmacotherapies and behavioral interventions targeting this symptom complex could be very helpful to affected youths and their
families. Also, this study result suggested that overplaying gaming might lead normal children develop more regressive or impulsive behavior and gradually more dysregulation in mood. The explosive emotional outbreak during their addiction withdrawal period among these internet addicted ADHD youth may be dangerous and should be diagnosed earlier during recently child and adolescent outpatient clinical practicing. For children and adolescent with ADHD, we should regard IGD as an alert lead a hazard of unhealthy growth and IGD must be diagnosed and treated earlier to prevent the later disruptive mood dysregulation.

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Author Chuan-Hsin Chang, Yue-Cune Chang, Helen Cheng, Ruu-Fen Tzang designed the study and wrote the protocol. Authors Yue-Cune Chang undertook the statistical analysis, and all authors contributed to and have approved the final manuscript.

Conflict of interest

The authors declare they have no conflict of interest.
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### Table 1: Characteristics of Patients with ADHD (Categorical Variable)

| Characteristics          | IA Internet Addiction (CIAS>56) | p-value<sup>a</sup> |
|---------------------------|---------------------------------|---------------------|
|                          | No (n=49)                       | Yes (n=52)         |
| Sex                       | Male                            | 38 (77.6%)         | 31 (59.6%) | 0.058 |
|                           | Female                          | 11 (22.4%)         | 21 (40.4%)|
| Performance               | Middle                          | 24 (50.0%)         | 23 (45.1%)| 0.689 |
|                           | Worse                           | 24 (50.0%)         | 28 (54.9%)|
| Interpersonal             | Good                            | 36 (75.0%)         | 24 (47.1%)| 0.007 |
|                           | Bad                             | 12 (25.0%)         | 27 (52.9%)|
| ODD                       | No                              | 15 (30.6%)         | 8 (15.4%) | 0.096 |
|                           | Yes                             | 34 (69.4%)         | 44 (84.6%)|
| DMDD                      | No                              | 23 (46.9%)         | 11 (21.2%)| 0.011 |
|                           | Yes                             | 26 (53.1%)         | 41 (78.8%)|
| Comorbidity               | Yes                             | 39 (79.6%)         | 52 (100.0%)| < 0.001 |
|                           | No                              | 10 (20.4%)         | 0 (0.0%)  |
| Subtype                   | Combined                        | 35 (71.4%)         | 30 (57.7%)| 0.212 |
|                           | Inattentive                     | 14 (28.6%)         | 22 (42.3%)|
| Family Psychiatric History| Yes                             | 11 (22.4%)         | 10 (19.2%)| 0.807 |
|                           | No                              | 38 (77.6%)         | 42 (80.8%)|
| Sibling with ADHD         | Yes                             | 11 (22.4%)         | 9 (17.3%) | 0.620 |
|                           | No                              | 38 (77.6%)         | 43 (82.7%)|
| Daily online              | More than 1hr                   | 23 (46.9%)         | 42 (80.8%)| < 0.001 |
| Chatting or Gaming        | Less than 1hr                   | 26 (53.1%)         | 10 (19.2%)|
| Weekend online            | More than 3hr                   | 21 (42.9%)         | 44 (84.6%)| < 0.001 |
| Chatting or Gaming        | Less than 3hr                   | 28 (57.1%)         | 8 (15.4%) |
| Treatment Effect          | Good                            | 14 (50.0%)         | 11 (31.4%)| 0.195 |
| Attend Parent Group | Bad    | 14 (50.0%) | 24 (68.6%) | 0.775 |
|---------------------|--------|------------|------------|-------|
| Program             | Yes    | 7 (23.3%)  | 8 (20.0%)  |       |
|                     | No     | 23 (76.7%) | 32 (80.0%) |       |
| Compliance          | Good   | 13 (48.1%) | 10 (27.8%) | 0.118 |
|                     | Bad    | 14 (51.9%) | 26 (72.2%) |       |

a: Fisher’s Exact test
Table 1 (Continue) Characteristics of Patients with ADHD (Continuous Variable)

| IA Internet Addiction (CIAS>=57) | No (n=49) | Yes (n=52) | p-value a |
|----------------------------------|-----------|------------|-----------|
| Height                           | 138.80 ± 18.15 | 148.72 ± 18.80 | 0.009     |
| Weight                           | 35.89 ± 15.06  | 45.94 ± 18.41  | 0.003     |
| Age                              | 10.16 ± 3.06   | 12.28 ± 3.73   | 0.002     |
| Father’s Age                     | 42.63 ± 6.30   | 46.94 ± 7.85   | 0.003     |
| Mother’s Age                     | 40.22 ± 7.25   | 43.60 ± 7.03   | 0.020     |
| SNAP_1_9                         | 20.02 ± 3.23   | 21.13 ± 3.72   | 0.112     |
| SNAP_10_18                       | 13.98 ± 7.11   | 14.00 ± 7.04   | 0.988     |
| SNAP_19_26                       | 12.20 ± 6.28   | 14.00 ± 4.66   | 0.108     |
| DMDD Total                       | 1.12 ± 1.15    | 1.92 ± 1.03    | < 0.001   |
| CIAS                             | 42.00 ± 10.66  | 72.81 ± 9.84   | < 0.001   |
| IGD(DSM-5)                       | 5.57 ± 4.59    | 14.77 ± 5.02   | < 0.001   |

a: Independent t-test

IA: internet addiction; ADHD: Attention deficit hyperactivity disorder; ODD: Oppositional defiant disorder; DMDD: Disruptive mood deregulation disorder; CIAS: Chen’s internet addiction scale; IGD: internet gaming disorder
Table 2 Comparing the Differences of the Clinical Measures for the 4-Week Treatment between IA and non-IA groups using the GEE’s method

| Measure       | Between-Group Difference in Score Changing Rate, Mean (SE) | 95% CI | Wald $\chi^2$ (p) |
|---------------|---------------------------------------------------------|-------|------------------|
|               | Baseline | Week 4 |                       |                   |                  |
| SNAP_1_9 IA   | N        | 20.02 ± 3.02 | 10.87 ± 5.27 | -9.370 (1.002)$^a$ | (-11.334 , -7.406) | 87.418 (<0.001) |
|               | Yes      | 21.13 ± 3.16 | 16.00 ± 5.67 | 4.101 (1.617)$^b$  | (0.932 , 7.269)  | 6.434 (0.011)   |
| SNAP_10_18 IA | N        | 13.98 ± 7.11 | 8.35 ± 6.53  | -6.477 (0.996)$^a$ | (-8.430 , -4.525) | 42.283 (<0.001) |
|               | Yes      | 14.00 ± 7.98 | 9.80 ± 6.76  | 1.526 (1.480)$^b$  | (-1.375 , 4.427) | 1.063 (0.303)   |
| SNAP_19_26 IA | N        | 12.20 ± 6.28 | 9.90 ± 4.59  | -2.947 (1.036)$^a$ | (-4.977 , -0.917) | 8.099 (0.004)   |
|               | Yes      | 14.00 ± 4.11 | 11.45 ± 6.22 | -0.501 (1.531)$^b$ | (-3.502 , 2.499) | 0.107 (0.743)   |
| DMDD Total IA | N        | 1.12 ± 1.12  | 0.77 ± 1.06  | -0.595 (0.215)$^a$ | (-1.017 , -0.173) | 7.635 (0.006)   |
|               | Yes      | 1.92 ± 1.20  | 1.20 ± 1.40  | 0.018 (0.304)$^b$  | (-0.579 , 0.615) | 0.004 (0.953)   |
| CIAS IA       | N        | 42.00 ± 10.66| 43.71 ± 11.00| 1.411(2.008)$^c$  | (-2.524 , 5.347) | 0.494 (0.482)   |
|               | Yes      | 72.81 ± 9.84 | 68.65 ± 7.26 | -5.951 (2.754)$^c$ | (-11.349 , 0.554) | 4.670 (0.031)   |
| DSM-5 IA      | N        | 5.57 ± 4.59  | 6.65 ± 4.39  | 0.728 (0.916)$^c$  | (-1.067 , 2.524) | 0.632 (0.427)   |
|               | Yes      | 14.77 ± 5.02 | 13.95 ± 4.62 | -1.768 (1.261)$^c$ | (-4.421 , 0.704) | 1.966 (0.161)   |

a: Treatment duration effect (Week 4 vs. Baseline) using GEE method’s multiple linear regression, after controlling for baseline severity.
b: Group-treatment duration (Week) interaction effect between two groups (IA vs. Non-IA) using GEE method’s multiple linear regression, after controlling for baseline severity.

c: GEE method’s multiple linear regression with group, treatment duration (in week), and their interaction terms in the model.

DMDD: Disruptive mood deregulation disorder; CIAS: Chen’s internet addiction scale
Table 3 Results of GEE Method’s Multiple Logistic Regression to Evaluate the Treatment Effects in Reducing the Risk of DMDD, after Adjusting for the Effects of Baseline Severity

| Parameter          | B    | Std. Error | Wald $x^2$ | df | Sig. | Odds Ratio (OR) | 95% Wald C.I. for OR |
|--------------------|------|------------|------------|----|------|-----------------|----------------------|
| (Intercept)        | -0.747 | 0.2572     | 8.429      | 1  | 0.004 | 0.474           | 0.286, 0.785         |
| DMDD_base          | 1.498  | 0.1835     | 66.634     | 1  | < 0.001 | 4.472           | 3.121, 6.408        |
| Week 4 vs. Baseline| -1.856 | 0.4073     | 20.766     | 1  | < 0.001 | 0.156           | 0.070, 0.347         |
| Week 3 vs. Baseline| -1.378 | 0.3493     | 15.568     | 1  | < 0.001 | 0.252           | 0.127, 0.500         |
| Week 2 vs. Baseline| -1.268 | 0.3892     | 10.613     | 1  | 0.001 | 0.281           | 0.131, 0.603         |

DMDD: Disruptive mood deregulation disorder
Table 4 Results of GEE Method’s Multiple Logistic Regression to Compare the Treatment Effects between IA and non-IA Groups in Reducing the Risk of DMDD, after Adjusting for the Effects of Baseline Severity

| Parameter       | B    | Std. Error | Wald $x^2$ | df | Sig. | Odds Ratio (OR) | 95% Wald C.I. for OR | Lower | Upper |
|-----------------|------|------------|------------|----|------|-----------------|----------------------|-------|-------|
| ( Intercept )   | -1.717 | 0.3649    | 22.147     | 1  | < 0.001 | 0.180          | 0.088 | 0.367 |
| DMDD_base       | 2.537 | 0.5259    | 23.268     | 1  | < 0.001 | 12.640        | 4.509 | 35.434 |
| IA vs. Non-IA   | 0.928 | 0.3996    | 5.387      | 1  | 0.020 | 2.528        | 1.155 | 5.533 |
| Week 4 vs. Baseline | -2.460 | 1.0642    | 5.345      | 1  | 0.021 | 0.085    | 0.011 | 0.688 |
| IA x Week 4     | -1.969 | 1.1805    | 2.781      | 1  | 0.095 | 0.140        | 0.014 | 1.412 |

IA: internet addiction; DMDD: Disruptive mood deregulation disorder