The Comparative Efficacy for Children and Young Adults With Internet Addiction/Internet Gaming Disorder: An Updated Meta-Analysis

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Abstract

Internet Game Disorder (IGD) is a formal mental disorder leading to bad outcomes for children and adolescents. While (Internet Addiction) IA/IGD is recognized, controversy remains about the treatment guidelines. This study comprehensively compares the estimated effect of various pharmacotherapy and psychosocial intervention for IGD from randomized controlled trials (RCT) by updated meta-analysis, meta-regression. A search of PubMed/MEDLINE, Cochrane Library, and Airiti Library between 2000 and 2017 was conducted for various IA/IGD intervention modalities. 124 studies from 29 selected papers involving 5,601 children and young adults with IA/IGD were found. The preliminary random effect is 1.399 with 95% confidence interval of 1.272-1.527 by meta-analyzing pooled standardized mean difference (SMD), suggesting highly effective treatment of IA/IGD. After adjusting for the confounding risks of age, publication year, type of subjects, and type of study, this study reveals combining pharmacotherapy with cognitive behavioral therapy (CBT) or multi-level counseling (MLC) is the most effective treatment option. Using scale of Online time spent scale or the severity of IA symptom scale were more effective measurement with p-values = 0.006 and 0.002, respectively. IA/IGD patients comorbid with depression showed worse outcomes than youth comorbid with another comorbidity. The corresponding model goodness-of-fit indices were $\tau^2 = 1.188$; I^2 -Residual=89.74%; and Adjusted- $R^2 = 16.10\%$. This systemic review provides clinicians with evidence that pharmacotherapy combined with cognitive behavioral therapy (CBT) or multi-level counseling (MLC) is an effective treatment for gaming disorder in children and young adults.

Introduction

Internet addiction (IA) or Internet Gaming Disorder (IGD) is rising significantly in prevalence among children and adolescents. Increasingly youth from all over world are accustomed to having access to smart phones and wireless Internet¹. The prevalence of pathological gaming in the United States and Europe is rising and ranges between 1.5–8.2% among the general population². In the child and adolescent population, gaming disorder prevalence as high as 8% was observed as well^{3–5}. Indeed, gaming disorder influences children's mental health world-wide: 2.1 to 2.6% of youth in North America, 0.2 to 4.4 % in Oceania, and 0.2 to 12.3 % of youth in Europe⁶.

Past research has found gaming disorder to be associated with the following bad mental health consequences for youth: academic decline, sleep deprivation⁷, interpersonal relationship problems, family conflict⁸, physical health problems, loneliness, suicidal ideation⁹, aggression, depression¹⁰, social withdrawal, dissociative experiences¹¹, cybercrimes¹², and future declines in workplace competitiveness¹³. There is a need to diagnose IGD earlier and provide effective early treatment strategies for gaming addicted youth. Moreover, an updated meta-analysis of the efficacy of gaming disorder is essential for clinicians' decision making.

In the literature, many pharmacotherapies and psychosocial approach are available as intervention for gaming disorder. In the past years, many psychosocial interventions for gaming disorder, including Cognitive Behavioral Therapy (CBT), Acceptance and Commitment Therapy (ACT), Reality Therapy (RT), and Multi-Level Counseling (MLC) programs, are rising stars in this field. The forms of psychological therapy intervention for youth with IA/IGD were delivered by individual session psychotherapy, family-based therapy, and group based supportive psychotherapy. Besides psychosocial intervention, using pharmacotherapy for youth with gaming disorder is increasing as well. Gaming disorder is often comorbid with other childhood neurodevelopmental disorders like Attention Deficit Hyperactivity Disorder (ADHD)¹⁴, Depression, or Anxiety¹⁰. Therefore, different antidepressant drugs, e.g. Escitalopram (for depression), Bupropion (for impulsivity)¹⁵, and psychostimulant drugs like Methylphenidate were all reported as effective for gaming disorder¹⁶. According to Winkler et al. in 2013, effective treatment options for internet addiction is combining pharmacological therapies with psychological intervention (with Hedges' $g = 1.61$) through a meta-analysis of a randomized control trial.

In 2017, both Zajac et al. and King et al. showed concerns about the quality of studies on the treatment interventions for gaming disorder in the past 10 years owing to a lack of well-established or updated meta-analysis on treatment outcome^{17–19}. Previously, Winkler et al. in 2013 found it difficult to estimate the effect of gaming disorder more thoroughly possibly due to a small sample size and insufficient availability of literature at that time²⁰. As a result, till now the long-term efficacy of combination therapy for IGD in youth remains still unknown. Therefore, here we strive to collect more randomized clinical trials, including various pharmacotherapy and psychosocial intervention of IA/IGD from Western and Eastern countries, to determine the best treatment intervention for gaming disorder with an updated meta- analysis.

In addition, the effect estimate can also be influenced by measurement tool use²¹. Widely used international screening tools, including the Internet Addiction Test (IAT), proposed by Young et al., in 1998²², the Compulsive Internet Use Scale (23) developed by Meerkerk et al., and the Problematic Internet Use Questionnaire (24) devised by Demetrovics et al. definitely were influencing effect size (ES) of internet addiction. Systematically reviewed a total of 45 scales, including 23 languages of existing Internet addiction scales and concluded that only 17 of the scales had been used to evaluate their psychometric properties²³. Also, the treatment effect of IA/IGD can be influenced by these

confounding variable like age, type of treatment, scales for treatment effect, types of comorbid diagnosis, types of study. Accordingly, there is a need to use an updated meta-analysis to systemically review the effect size (ES) of Internet addiction by different IA/IGD screening measurements for children and young adults.

Meta-regression is an extension to subgroup analyses that allows the effect of continuous, as well as categorical, characteristics to be investigated, and in principle allows the effects of multiple factors to be investigated simultaneously. Therefore, meta-regression can use even the continuous, as well as categorical symptom scale to investigate unbiased efficacy. Meta-regression is an effective tool for exploratory analyses of heterogeneity and for studies of cross-level interactions²⁴. The heterogeneity can be reduced through interaction analysis (stratified or sub-group analysis)²⁵. Meta-regression can merge meta-analysis and linear regression principles to better clarify the linear relationship of various outcome measures, and thereby provide clinicians and healthcare decision makers with more valuable information than meta-analysis²⁶. Accordingly, in this study, we first compare the effect size of pharmacotherapy and psychosocial treatments of IGD by updated meta-analysis. We will explore meta-regression to whether those aforementioned potential confounding risk factors, e.g., age, type of treatment, scales for treatment effect, types of comorbid diagnosis, types of study designed data, group therapy (Yes vs. No), and parental involvement in the therapy program (Yes vs. No) can influence the treatment effects of IA/IGD in children and young adults. Such systemic review by meta-regressions of randomized controlled trials is a vital way to provide clinicians with the confidence to choose the right treatment option for Internet gaming disorder for youth.

Methods

Search and Study selection

We searched four databases (PubMed, Cochrane Library, SCOPUS, and Airiti Library) for articles published between 2000 and 2017. Two independent scientists (Chang and Tzang) screen the literature and identified meta-analysis of randomized control trial studies of the efficacies for IA/IGD in children and young adults.

The following full electronic search strategies were used: ("Internet Addiction" OR "Internet Gaming Disorder" OR "Problematic Internet Use" OR "Internet Usage" OR "Internet Overuse" OR "Problematic Internet" OR "Online Addiction" OR "Cybersex" OR "Computer Game Addiction") AND (treatment OR therapy OR program OR training OR psychotherapy OR curriculum OR psychosocial OR Escitalopram OR Methylphenidate OR Bupropion OR Atomoxetine OR Fluoxetine OR pharmacological OR non-pharmacological OR behavior OR Treat* OR Therapy* OR Intervention OR Psychotherapy) AND (child OR "elementary students" OR adolescent OR "Young Adult"). To avoid overlooking any crucial studies, we also searched reference lists of the retrieved articles to identify other eligible studies.

Inclusion and Exclusion criteria

Studies were included if they met the following inclusion criteria: (1) the study addressed the "internet addiction" topic (or related topic, e.g. internet gaming disorder); (2) the age of all participants was less than 25 years (intended to include college students); (3) the study included a pharmacological or non-pharmacological treatment (mainly psychological without excluding others, e.g. alternative medicines or therapies) aimed to decrease IA related problems (mainly, severity of IA, online time spent, depression and anxiety).

Studies meeting the following criteria were excluded: (1) the study did not provide sufficient information to evaluate the (Hedges' *g*) effect sizes, and, the authors did not response to our mail or willing to provide additional information; (2) the study did not report results for at least one of the aforementioned four outcome variables; (3) the study was a case study; (4) unavailability of the full text of the study; (5) repeated study or the participants overlapped either partially or completely with the subjects of another study or any one included in a meta-analysis. There were 124 eligible studies constituted this study after application of the inclusion and exclusion criteria.

Data Extraction

The following is all variable for efficacy of gaming disorder: (1) the last name of the first author, (2) publication year, (3) type of treatment interventions, (4) the treatment durations (in weeks), (5) number of subjects in the analysis, (6) mean age of subjects, (7) type of comorbid diagnosis (IA, IA+ADHD, and IA+ Depression), (8) type of scales used to evaluate the treatment effects, (9) group therapy (Yes vs. No), and (10) parents involved in the therapy program (Yes vs. No).

Type of treatment interventions

To explore potential influential factors and reduce heterogeneity, we had recoded the type of treatment intervention, type of scales used to evaluate the treatment effects, and the types of subjects as following. Treatment interventions were classified as following five type of

treatment: (1) **Treat 1:** Drugs (Methylphenidate, Escitalopram, Bupropion, Atomoxetine, and Fluoxetine); (2) **Treat 2:** CBT (Cognitive Behavioral Therapy), Positive Psychology Interventions, Psychological Intervention, Traditional Psychology Intervention, and Integrated Internet Addiction Prevention Program); (3) **Treat 3:** MLC (Multi-level Counseling Program), Solution-Focused Brief Therapy (SFBT) with Family Therapy, Adlerian Group Counseling, Multi-family Group Therapy, Solution-Focused Group Counseling, Interpersonal Group Program); (4) **Treat 4:** Drug + CBT or MLC; (5) **Treat 5:** Others + CBT or MLC; (6) **Treat 6:** Others (Electro-acupuncture (EA), Psychology Nursing Intervention, Sports, Negative Health Effect Intervention, Adlerian Group Counseling, Electroencephalographic (EEG) Biofeedback Treatment, Han's acupoint nerve stimulation (HANS), and Knowledge, Altitude, Belief, and Practice (KABP)).

Type of symptom measurement scales

The type of scales used to evaluate the treatment effects were classified as follows: (1) **Type 1: Anxiety** (Hamilton Anxiety Scale (HAMA), Screening for Child Anxiety Related Emotional Disorders (SCARED), Self-Rating Anxiety Scale (SAS), SCL-90_Anxiety, State-Trait Anxiety Inventory (STAI)); (2) **Type 2: Depression** (Hamilton Depression Scale (HAMD), Hamilton Depression Rating Scales (HDRS), Self-Rating Depression Scale (SDS), SCL-90_Depression; Children Depression Inventory (CDI)); (3) **Type 3: Severity of internet addiction** (Chen/Chinese Internet Addiction Scale (CIAS), Chinese Internet Addiction Scale Revised (CIAS_R), Computer Gaming Addiction Intervention (CGAI), Checklist for the Assessment of Internet and Computer Game Addiction (AICA-C), Impulsive-Compulsive Internet Use Disorder version of the Yate-Brown Obsessive Compulsive Scale (IC-IUD-YBOCS), IAD (Internet Addiction Disorder), self-rating scale (ISS), Internet Addiction Disorder Diagnosis Questionnaire (IAD_DQ), Young's Diagnostic Questionnaire for Internet addiction (YDQ), Young Internet Addiction Scale (YIAS), YIAS-Korean version (YIAS-K), Internet Overuse Self-Rating Scale (IOSRS), Callan Internet Use Scale (CIUS), Self-rating Internet Using Scale (SIUS), Internet Addiction Test (IAT), Adolescent Pathological Internet Use Scale (APIUS), IA Knowledge, Altitude, and Practice (KAP); (4) **Type 4: Online time spent scale** (Time Management Disposition Scale (TMDS), the severity of Internet use (Hours of Internet Use, SI); (5) **Type 5: Others** (SCL-90 (Total), Strength and Difficulties Questionnaire (SDQ), Negative health effect (NHE)).

Type of comorbid diagnosis

The types of comorbid diagnosis were classified as follows: (1) **PType 1:** IA; (2) **PType 2:** IA comorbid with depression (IA + Depression); (3) **PType 3:** IA comorbid with ADHD (IA+ ADHD).

Types of study design

The term 'effect size' is frequently used in the social sciences, particularly in the context of meta-analysis. Effect sizes typically refer to versions of the standardized mean difference (SMD) as Hedges' (adjusted) g . However, the value of SMD will be influenced significantly by the choice of control group, mainly, depends on whether the study used an active control (e.g., Drug (Methylphenidate) vs. Drug (Atomoxetine)) or a placebo control (e.g. Drug (Methylphenidate) vs. Placebo). The value of SMD of later should be significantly higher than the former. To be comparable and consistent, in this study, we classified types of study design as follows: (1) **StudType 1:** For placebo control studies with available mean pre-post change, the SMD of Hedges' g was calculated using the mean pre-post change in both treatment and control groups. For comparing with active control studies, we treated this type of study as there were two independent groups with mean pre-post change available and calculated each group's unbiased SMDs of Hedges' g according to the following StudType 2; (2) **StudType 2:** One group with mean pre-post change available, for convenience, we first used 0.7 as the correlation coefficient between pre- and post-treatment scores to estimate the standard errors of the changes. And then, we used the mean pre-post change and the standard errors of the changes to calculate the unbiased SMD of Hedges' g ; (3) **StudType 3:** Two groups with mean post-treatment scores available only, that is, the pre-test information of both groups were not presented in the study. The unbiased SMD of Hedges' g was calculated using the post-test means and standard deviations from both treatment and control groups; (4) **StudType 4:** A meta-analysis paper, sometimes, only presented unbiased SMD of Hedge's g and its standard errors. In that case, we used both information directly to analyze.

Statistical analysis

Computer application is using STATA/SE version V13.0 for WINDOWS software (Stata Corporation, College Station, TX) to analyze all data. We first used the fixed effects meta-analysis to evaluate the pooled effects size. The random effects meta-analysis will be followed if the testing results of between studies' heterogeneity is highly significant.

However, the SMDs of Hedges' g were expected to be comparable but not identical across studies due to highly significant heterogeneity among them (e.g., 5 types of treatment intervention and 6 types of IA scales). For example, there were five types of scales used to evaluate the effect size and as shown in previous section, each scale type included many different formats' scales under same evaluation purpose. It should be noted that the SMD method does not correct for differences in the direction of the scale. Among all evaluation scales, there were mainly two different kinds of trends to represent the treatment effects, that is, either the higher value represents the better treatment effect

or, from the reverse direction, the worse effect. If some scales it is essential to multiply the mean values from one set of studies by -1 (or alternatively to subtract the mean from the maximum possible value for the scale) to ensure that all the scales point in the same direction. To be consistent and to facilitate the interpretation of the results, we rearranged all the values of SMDs of Hedges' (adjusted) g be in one direction according to the characteristics of their original scales, that is, a larger effect size indicates a better effect estimate.

Additional analysis

Meta-regression is appropriate for testing whether certain confounders on the outcome, selected variables (the independent variables) on the effect size (the dependent variable). The influence of the meta-regression analyses was used to compare the potential influential factors on treatment effect. The dependent variable was the SMD of Hedges' (adjusted) g and assessed by the aforementioned four types of study designed data. The independent variables were publication year, treatment duration, mean age, and aforementioned recoded type of treatment, scales for treatment effect, types of comorbid diagnosis, types of study designed data, group therapy (Yes vs. No), and parents involved in the therapy program (Yes vs. No). The risk of bias was evaluated by funnel plots and Egger's regression intercept tests for bias. The level of significance was set at $p < 0.05$.

Results

In total, meta-analysis of 124 studies 5,601 subjects with IA/IGD (or comorbid with Depression or ADHD), extracted from 29 published papers of the effects of various treatment interventions (Table 1). Two of them were conducted in Taiwan, four were conducted in USA, and one was conducted in Iran. The remainders were published by the researchers from mainland China or Korea. A detail summary of the characteristics of all the included clinical trials was presented in Table 1. Those 29 published papers listing of the detail name of the first author and the titles were shown in the supplementary Table S1.

Table 1
Summary of study characteristics of all included papers

Paper	Year	Country	No of Studies	Age	Measurements	No. of Patients	Treatment Sections	Type of Subjects	Treatment
Cao FL et al	2007	China	1	14.8	YDQ, CIAS	57	8	IA	CBT vs. Control
Li G & Dai XY	2009	China	1	16.5	CIAS	76	12	IA	CBT vs. Control
Shao Z et al	2015	China	1	16	SDS, SCL-90	66	8	IA + Depression	CBT + Drug vs. CBT
Wei QX	2008	China	1	17	SAS, SDS	60	12	IA	Others (Psychology Nursing) vs. Control
Yang FR et al	2005	China	1	15.2	IAD-DQ, SCL-90, Time	52	12	IA	SFBT (No control)
Liao XC	2010	China	1	15	IAD-DQ, SCL-90	284	32	IA + Depression	CBT + Drug vs. CBT
Wu LZ et al	2007	China	1	19.5	Time	27	6	IA	Others (HANS) vs. Control
Pan SJ et al	2010	China	1	17	CIAS, SCL-90, SDS	11	16	IA	Others (EEG Biofeedback) (No control)
Liao YR et al	2012	Taiwan	1	14	CIAS-R, Time	18	8	IA	Others (Adlerian Group Counseling) vs. Control
Li & Dai	2009	China	1	16.5	CIAS	76	9	IA	CBT vs. Control
Bai & Fan	2007	China	1	19	CIAS	48	8	IA	MLC vs. Control
Du YS et al	2010	China	1	15.9	IOSRS	56	8	IA	CBT vs. Control
Han DH et al	2009	Korea	1	9.3	YIAS-K, Time	62	8	IA + ADHD	Drug(Methylphenidate) (No control)
Yang R et al	2005	China	1	16	CIUS, SDS, SCL-90	18	8	IA	MLC + Drug(Fluoxetine) + Others (No control)
Zhu TM et al	2009	China	1	22.2	ISS, SAS, SDS, HAMA, HAMD	45	20, 10	IA	CBT + acupuncture vs. CBT
Yeun YR et al.	2016	Korea	33	8 ~ 12	K-scale, YIAS, IGAS	1330	6 ~ 22	IA	CBT, MLC, CBT/MLC + Others, Others
Liu J et al.	2017	China, Korea	49	15.5 ~ 20	IA	2304		IA	CBT, MLC, Others
Winkler et al.	2013	China, Korea, US	16	14.8 ~ 23	Anx., Dep., IA, Time	454		IA	Drug, CBT, MLC, Others
Liu QX et al	2015	China	1	15.7	APIUS, Time	46	6	IA	MLC vs. Control

RP: Routine Pharmacotherapy

Paper	Year	Country	No of Studies	Age	Measurements	No. of Patients	Treatment Sections	Type of Subjects	Treatment
Yang Y et al.	2017	China	1	21.1, 21.7	YIAS	32	10, 20	IA	CBT vs. Electro-acupuncture
Han DH et al.	2012	Korea	1	20.2	YIAS, BDI, Time	50	8	IA + Depression	Drug (Bupropion)
Park JH et al.	2016	Korea	1	17	YIAS, CDI	86	12	IA + ADHD	Drug (Methylphenidate) vs. Drug (Atomoxetine)
Mun SY et al	2015	Korea	1	10.5	IA, Time	56	8	IA	CBT vs. Control
Lien T.-C.	2007	Taiwan	1	16.8	YDQ	20	8	IA	MLC vs. Control
Huang Z et al	2010	China	1	21	CGAI	27	6	IA	MLC vs. Control
Khazaei et al.	2017	Iran	1	20	YIAS	48	10	IA	CBT (Positive psychology Interventions) vs. Control
Hui Li et al	2017	China	1	22	ISS, SCL-90	112	10	IA	CBT + Others (EA) vs. CBT vs. Others (EA)
Kim SM et al.	2012	Korea	1	16	YIAS, BAI, BDI, Time	65	8	IA + Depression	CBT + Drug (Bupropion) vs. Drug (Bupropion)
Han DH et al	2012	Korea	1	14.2	YIAS, Time	15	12	IA	MLC (No control)
RP: Routine Pharmacotherapy									

Using SMD as the pre-specified effect size, the fixed effect meta-analysis showed that there was a positive and effective overall pooled effect with a highly significant heterogeneity (chi-squared = 2951.24, d.f. = 206, $p < 0.001$). Accordingly, the random effects meta-analysis was followed and the pooled overall effect = 1.399 (with 95% confidence interval of 1.272, 1.527). The level of evidence of the included studies showed the variation in ES attributable to heterogeneity, I-squared, was 93.0%, and the estimate of between-study variance, Tau-squared, was 0.7492.

The meta-regression analysis was used to explore the potentially influential factors on the high heterogeneity of ES. In Table 2, the results of univariate meta-regression showed that: ignored other potential influencing factors' effects, (1) Age effect: the treatment effect on IA/IGD significantly increased while age increased ($p = 0.013$). (2) Treatment effect: pharmacotherapy combined with the cognition behavioral therapy or MLC (Treat 4) was the best treatment type among those five types of treatment modal of IA/IGD. (3) Measurement scale effect: the treatment effect was better while using measurement named the Internet online time spent (Type 4) followed by the severity of Internet addiction scale (Type 3). (4) publication year, types of SMD, types of diagnosis, group therapy (Yes vs. No), and parents involved in the therapy program (Yes vs. No) had no significant impacts on the treatment effects.

Table 2
Results of univariate meta-regression analysis

SMD	Coefficients	SE	t	p	τ^2	I ² -Residual	Adjusted-R ²	No.
Year	0.025	0.027	0.93	0.354	1.415	93.00%	0.05%	207
Mean Age	0.062	0.025	2.51	0.013	1.36	92.52%	3.99%	207
Treatments					1.39	93.00%	1.83%	207
Treat 2 vs. Treat 1	0.613	0.320	1.92	0.056				
Treat 3 vs. Treat 1	0.263	0.311	0.85	0.398				
Treat 4 vs. Treat 1	0.834	0.427	1.96	0.052				
Treat 5 vs. Treat 1	0.665	0.408	1.63	0.104				
Treat 6 vs. Treat 1	0.269	0.377	0.71	0.477				
Measurements					1.39	91.89%	1.80%	207
Type 2 vs. Type 1	0.137	0.384	0.36	0.722				
Type 3 vs. Type 1	0.533	0.309	1.73	0.086				
Type 4 vs. Type 1	0.744	0.406	1.83	0.068				
Type 5 vs. Type 1	-0.107	0.531	-0.20	0.841				
Study Types					1.432	92.87%	-1.13%	207
StudType 2 vs StudType 1	-0.077	0.265	-0.29	0.772				
StudType 3 vs StudType 1	-0.298	0.310	-0.96	0.338				
StudType 4 vs StudType 1	-0.211	0.267	-0.79	0.429				
Types of Subjects					1.402	92.66%	1.01%	207
PType 2 vs. PType 1	-0.487	0.356	-1.37	0.172				
PType 3 vs. PType 1	-0.726	0.526	-1.38	0.169				
Group Therapy					1.420	93.01%	-0.29%	207
Yes vs. No	-0.126	0.188	-0.67	0.503				
Parents Involved in the Therapy program					1.441	93.07%	-0.02%	203
Yes vs. No	0.188	0.221	0.85	0.396				

Treatments: **Treat 1:** Drugs; **Treat 2:** CBT (Cognitive Behavioral Therapy); **Treat 3:** MLC (Multi-level Counseling Program);

Treat 4: Drug +CBT or MLC; **Treat 5:** Others + CBT or MLC; **Treat 6:** Others;

Measurements: **Type 1:** Anxiety; **Type 2:** Depression; **Type 3:** Internet Addiction Scale; **Type 4:** Online Time Spent (Hours of Internet Use);

Type 5: Others;

Study Types: **StudType 1:** Two groups with pre- and post-tests; **StudType 2:** One group with pre-test and post-test;

StudType 3: Two groups post-test only; **StudType 4:** Using Hedge's g and se(G) directly;

Types of Subjects: **PType 1:** IA; **PType 2:** IA+Depression; **PType 3:** IA+ADHD.

We further used the multiple meta-regression models to explore the confounding risk on the effect estimate after mutually adjusting for the effects of other risk factors in the model. The merit of this study was that we rearranged all the values of SMDs of Hedges' *g* to be in one direction according to the characteristics of their original scales, that is, a larger value to indicate a better treatment effect. Under this setting, this way let the results of meta-regression model become interpretable. As shown in Table 3, after adjusting for risk of treatments type and measurement scales on effect estimate, the effect size significantly increased (on average) by 8.7% for each increasing 1 year the

mean age of IA/IGD youth ($p = 0.001$). Similarly, after adjusting for the effects of mean age and type of measurement scales, the effect estimate was significantly higher by using pharmacotherapy + CBT or MLC (Treat 4), Others + CBT or MLC (Treat 5), and CBT (Treat 2) than that by using pharmacotherapy alone (Treat 1) by 1.175, 0.829, and 0.623 standard deviations, respectively, with p -values = 0.005, 0.039, and 0.049, respectively. The effect size were significantly higher by using measurement scale Type 4 (Online Time Spent) and measurement scale Type 3 (Severity of Internet Addiction) than that of using measurement scale Type 1 (Anxiety) by 1.171 and 0.880 standard deviations, respectively, with both p -values = 0.004 after adjusting risks of mean age and type of treatments.

Table 3
Results of multiple meta-regression analysis (Using significant terms only)

SMD	Coefficients	SE	t	p	τ^2	I ² -Residual	Adjusted-R ²	No.
					1.209	90.32%	14.65%	207
Mean Age	0.087	0.025	3.53	0.001				
Treatments								
Treat 2 vs. Treat 1	0.623	0.315	1.98	0.049				
Treat 3 vs. Treat 1	0.152	0.309	0.49	0.624				
Treat 4 vs. Treat 1	1.175	0.409	2.87	0.005				
Treat 5 vs. Treat 1	0.829	0.399	2.08	0.039				
Treat 6 vs. Treat 1	0.382	0.370	1.03	0.302				
Measurements								
Type 2 vs. Type 1	0.232	0.369	0.63	0.531				
Type 3 vs. Type 1	0.880	0.304	2.89	0.004				
Type 4 vs. Type 1	1.171	0.398	2.94	0.004				
Type 5 vs. Type 1	-0.089	0.504	-0.18	0.860				

τ^2 : The estimate of between-study variance;

I²-Residual: Residual variation due to heterogeneity in percentage;

Adjusted-R²: Proportion of between-study variance explained by the current model.

Treatments: **Treat 1:** Drugs; **Treat 2:** CBT (Cognitive Behavioral Therapy); **Treat 3:** MLC (Multi-level Counseling Program);

Treat 4: Drug +CBT or MLC; **Treat 5:** Others + CBT or MLC; **Treat 6:** Others;

Measurements: **Type 1:** Anxiety; **Type 2:** Depression; **Type 3:** Internet Addiction Scale; **Type 4:** Online Time Spent (Hours of Internet Use);

Type 5: Others;

Random-effects models have an underlying assumption that a distribution of effects exists, resulting in heterogeneity among study results, known as τ^2 , the I-squared residual, was 90.32%. The proportion of the between-study variance explained by the meta-regression model, adjusted R-squared, was 14.65%. The corresponding meta-regression plot is shown in Fig. 1.

We also tried to use those extracted data and additional results of meta-regression in Table 1, 2, and 3 to improve the goodness-of-fit indices both quantitatively (I-squared residual and adjusted R-squared) and visualized (Figure). The results of best fitted model were shown in Table 4 and we summarized our findings as follows: (1) the major results were consistent with those presented in Table 3, (2) after adjusting confounding risks of age, publication year, type of comorbid diagnosis, and type of study design, the best effective treatment intervention was pharmacotherapy combined with CBT or MLC in reducing the Internet online time spent (Type 4) followed by lowering the severity of Internet addiction (Type 3), with p -values = 0.006 and 0.002, respectively, (3) among three types of comorbid diagnosis (IA, IA comorbid with Depression, and IA comorbid with ADHD), those youth with IA comorbid with depression (Type 2) had worst treatment effects, after adjusting for the effects of other factors presented in the model, (4) the corresponding residual variation due to the

heterogeneity in this meta-regression model, the I-squared residual, was 89.74%. The proportion of between-study variance explained by the meta-regression model, adjusted R-squared, was 16.1%. The corresponding meta-regression plot is shown in Fig. 2.

Table 4
Results of multiple meta-regression analysis (with all collected potential confounding variables)

SMD	Coefficients	SE	t	p	τ^2	I ² -Residual	Adjusted-R ²	No.
					1.188	89.74%	16.10%	207
Mean Age	0.125	0.037	3.33	0.001				
Treatments								
Treat 2 vs. Treat 1	0.528	0.365	1.45	0.150				
Treat 3 vs. Treat 1	0.092	0.374	0.25	0.805				
Treat 4 vs. Treat 1	1.044	0.458	2.28	0.024				
Treat 5 vs. Treat 1	0.505	0.462	1.09	0.276				
Treat 6 vs. Treat 1	0.171	0.422	0.41	0.685				
Measurements								
Type 2 vs. Type 1	0.283	0.370	0.76	0.446				
Type 3 vs. Type 1	1.027	0.321	3.20	0.002				
Type 4 vs. Type 1	1.125	0.409	2.75	0.006				
Type 5 vs. Type 1	-0.318	0.514	-0.62	0.536				
Year	-0.007	0.030	-0.22	0.823				
PType 2 vs. PType 1	-0.681	0.383	-1.78	0.077				
PType 3 vs. PType 1	-0.323	0.624	-0.52	0.605				
StudType 2 vs. StudType 1	0.115	0.301	0.38	0.702				
StudType 3 vs. StudType 1	0.131	0.420	0.31	0.757				
StudType 4 vs. StudType 1	-0.553	0.280	-1.97	0.050				

Treatments: **Treat 1:** Drugs; **Treat 2:** CBT (Cognitive Behavioral Therapy); **Treat 3:** MLC (Multi-level Counseling Program);

Treat 4: Drug +CBT or MLC; **Treat 5:** Others + CBT or MLC; **Treat 6:** Others;

Measurements: **Type 1:** Anxiety; **Type 2:** Depression; **Type 3:** Internet Addiction Scale; **Type 4:** Online Time Spent (Hours of Internet Use);

Type 5: Others;

Study Types: **StudType 1:** Two groups with pre- and post-tests; **StudType 2:** One group with pre-test and post-test;

StudType 3: Two groups post-test only; **StudType 4:** Using Hedge's g and se(G) directly;

Types of Subjects: **PType 1:** IA; **PType 2:** IA+Depression; **PType 3:** IA+ADHD.

The risk of bias was assessed by funnel plots and Egger's regression intercept tests for bias. As shown in Fig. 3, the publication bias was significant (p-value < 0.001). In other words, there existed some potential bias within study.

Discussion

To our knowledge, this additional meta-regression is the largest updated meta-analysis done in the field of gaming disorder. Compared to the 16 studies and 670 participants in the general population 8 years ago by Winkler et al ²⁰, this meta-regression used 124 studies and 5,601 children and young adults to contribute to the rapid development of this field.

Like previous meta-analysis of efficacy of gaming disorder in 2013, this study also found combination therapy with pharmacotherapy and cognitive behavioral therapy (CBT) or multi-level counseling (MLC) to be the best treatment type among those five types of IA/IGD treatment modal. The scale used is online time spent scale or the severity of internet addiction symptom scale is better measurement tool for studying efficacy of gaming disorder. The most interesting finding is gaming disorder comorbid with depression got poorer treatment effect than patients comorbid with ADHD.

The prevalence of Internet addiction has increased dramatically, with 1000% proliferating occurring²⁷. Especially during a lockdown due to the COVID-19 pandemic, gaming disorder might bring severely bad impact to adolescent mental health²⁸. When a child or adolescent excessively uses internet gaming, they may first become unable to prioritize or keep schedules, avoid work, or procrastinate, and then followed by symptoms of depression or anxiety, even appear agitated when forced to stop using the computer by a caregiver. Therefore, gaming addicted youth urgently need an early and effective treatment and prevention program²⁹.

Internet addiction and internet gaming disorders are not just creating an important public health problem for youth. In 2016, Sepede et al. published a systematic review based on a total of 18 related articles (666 patients in total). The brains of these victims of gaming disorder showed defects in the cortical and subcortical regions of the orbitofrontal cortex, insula, anterior and posterior cingulate cortex, temporal lobe, parietal lobe, brain stem, and caudate nucleus³⁰. Such defects are directly/indirectly just like substance addiction and cause dysfunction on cognitive control and brain reward processing of youth. Therefore, this is why after a long debate, the World Health Organization (WHO) in 2018 decided to include internet gaming disorder (IGD) as a formal mental disorder in the 11th revision of the International Classification of Diseases (ICD-11) for the better treatment and early prevention for those children and adolescents with gaming disorder³¹.

Therefore, parents, sociologists, psychologists, and psychiatrists worldwide all start to seek various treatment interventions. Fundamentally, the choice of which gaming disorder interventions to use shows a strong cultural bias. Generally, advanced countries with a well-funded mental healthcare system prefer evidence-based combination therapy as the first-line treatments while some developing country prefer to use concentration camps even though the correction program was reported as largely ineffective intervention³². Still in many Asian countries, especially in China or Korea, the "boot camp" styled correction program of managing gaming disorder is extremely popular. Of course, this phenomenon of parent's irrational choice of treatment reflects parents' unwillingness to accept that Internet addiction is a mental disorder or the parent's misunderstanding that pharmacological treatment is harmful for gaming addicted youth. Thus, one important aspect of this research is to encourage all the parents of gaming disordered youth to diagnose IGD early along with any of its common comorbid mental disorders, e.g. ADHD, depression, and treat them with an appropriate combination intervention to prevent bad consequence in the future.

In order to strengthen the mental health education of youth worldwide with gaming disorder, governments around the world should promote appropriate and effective treatment guidelines including how much time youth should spend online, early recognition and diagnosis of IGD, and proper simultaneous treatment of comorbid mental health disorders and gaming disorder. The authors suggest the following as a starting point for promoting appropriate and effective treatment guidelines: For those teenagers not yet a victim of gaming disorder, appropriate professional counseling for children, adolescent self or their family and timely screening of IGD is necessary³³. The rule of thumb is establishing healthy online use habits early and timely prevention of children falling victim to gaming disorder. For those youth with gaming disorder, the comorbid diagnosis of gaming disorder should be made and treated early by a child psychiatrist. A better treatment outcome can be reached while comorbid ADHD or depression when treated properly with a combination of pharmacotherapy and psychosocial therapy.

The shortcoming of this study is this paper pertains to Internet Addiction (IA) as well as Internet Gaming Disorder (IGD). None of the treatment intervention studies separated the treatment of Internet gaming addiction and Internet addiction because both Internet gaming addiction and Internet addiction fall under the DSM-V classification of IGD. Because none of the treatment intervention studies separated the treatment effect respectively according to treatment outcome of Internet gaming addiction and Internet addiction till now. In diagnosis of IGD from the DSM-V, they lump both gaming and Internet addiction together into IGD. In the future, a well-designed psychometric study for evaluating the treatment effect of both IGD and IA separately is warranted. Another limitation is the present study of effect estimate lacks long-term following up data to assess treatment effect durability. Finally, although we planned to identify all the studies from both Western and Eastern countries, despite a robust search strategy, our search results only found results from Asian countries, mainly Chinese and Korean studies. Thus, in this study, most of our included papers were published by researchers from China and South Korea. This might limit worldwide-generalized conclusion based on this finding. We admit our database research is from PubMed/MEDLINE, Cochrane Library, and Airiti Library and not the PsycInfo database which includes more research on psychological treatments. This might be another limitation.

Conclusions

The value of this article is to reinforce Winkler's previous results. We included all the articles in either English or Chinese, and all of the existing interventions even including alternative therapy like biofeedback, acupuncture and electro-acupuncture, more comorbid diagnosis including ADHD, depression, anxiety, more measurement tools, more confining to child and young adult for meta-regression analysis which makes the study results more significant.

In short, this systemic review, meta-regression of randomized clinical trial studies can provide the child mental health professional with an effective treatment modal for gaming disorder. This meta-regression results brought interest to clinicians to earlier diagnose youth with internet gaming disorder. More psychiatrists must be invited to join in the prevention of internet gaming disorder. Also, government policy makers for adolescent mental health should encourage more child and adolescent psychiatrists to provide pharmacotherapy combined with cognitive behavioral therapy (CBT) or multi-level counseling (MLC) to get the best treatment outcome.

Declarations

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Disclosure Statement

None of the authors has conflict of interest.

Author Contributors

R.F. Tzang, Y.C. Huang, Luke Yang, and Y.C. Chang conceived the presented idea and designed the study. Y.C. Huang, Luke Yang, and Y.C. Chang performed the statistical analysis of the data. All authors discussed the results and contributed to the final manuscript.

References

1. Chamberlain, S. R. *et al.* Behavioural addiction-A rising tide? *Eur. Neuropsychopharmacol.* **26**, 841–855 <https://doi.org/10.1016/j.euroneuro.2015.08.013> (2016).
2. Weinstein, A. & Lejoyeux, M. Internet addiction or excessive internet use. *Am. J. Drug Alcohol Abuse.* **36**, 277–283 <https://doi.org/10.3109/00952990.2010.491880> (2010).
3. Kilic, M., Avci, D. & Uzuncakmak, T. Internet Addiction in High School Students in Turkey and Multivariate Analyses of the Underlying Factors. *J. Addict. Nurs.* **27**, 39–46 <https://doi.org/10.1097/JAN.0000000000000110> (2016).
4. Floros, G. *et al.* Adolescent online gambling in Cyprus: associated school performance and psychopathology. *J. Gambl. Stud.* **31**, 367–384 <https://doi.org/10.1007/s10899-013-9424-3> (2015).
5. Gentile, D. Pathological video-game use among youth ages 8 to 18: a national study. *Psychol. Sci.* **20**, 594–602 <https://doi.org/10.1111/j.1467-9280.2009.02340.x> (2009).
6. Calado, F., Alexandre, J. & Griffiths, M. D. Prevalence of Adolescent Problem Gambling: A Systematic Review of Recent Research. *J. Gambl. Stud.* **33**, 397–424 <https://doi.org/10.1007/s10899-016-9627-5> (2017).
7. Kim, S. Y., Kim, M. S., Park, B., Kim, J. H. & Choi, H. G. Lack of sleep is associated with internet use for leisure. *PLoS One.* **13**, e0191713 <https://doi.org/10.1371/journal.pone.0191713> (2018).
8. Schneider, L. A., King, D. L. & Delfabbro, P. H. Family factors in adolescent problematic Internet gaming: A systematic review. *Journal of behavioral addictions.* **6**, 321–333 <https://doi.org/10.1556/2006.6.2017.035> (2017).
9. Lee, S. Y. *et al.* The Association of Level of Internet Use with Suicidal Ideation and Suicide Attempts in South Korean Adolescents: A Focus on Family Structure and Household Economic Status. *Can. J. Psychiatry.* **61**, 243–251 <https://doi.org/10.1177/0706743716635550> (2016).
10. Ahmadi, J. *et al.* Prevalence of Addiction to the Internet, Computer Games, DVD, and Video and Its Relationship to Anxiety and Depression in a Sample of Iranian High School Students. *Iran J Psychiatry Behav Sci.* **8**, 75–80 (2014).
11. De Pasquale, C., Dinaro, C. & Sciacca, F. Relationship of Internet gaming disorder with dissociative experience in Italian university students. *Ann Gen Psychiatry.* **17**, 28 <https://doi.org/10.1186/s12991-018-0198-y> (2018).

12. Ma, H. K. Internet addiction and antisocial internet behavior of adolescents. *ScientificWorldJournal*. **11**, 2187–2196 <https://doi.org/10.1100/2011/308631> (2011).
13. Yamada, T., Moshier, S. J. & Otto, M. W. No site unseen: predicting the failure to control problematic Internet use among young adults. *Cogn. Behav. Ther.* **45**, 496–500 <https://doi.org/10.1080/16506073.2016.1205657> (2016).
14. Wang, B. Q., Yao, N. Q., Zhou, X., Liu, J. & Lv, Z. T. The association between attention deficit/hyperactivity disorder and internet addiction: a systematic review and meta-analysis. *BMC Psychiatry*. **17**, 260 <https://doi.org/10.1186/s12888-017-1408-x> (2017).
15. Nam, B., Bae, S., Kim, S. M., Hong, J. S. & Han, D. H. Comparing the Effects of Bupropion and Escitalopram on Excessive Internet Game Play in Patients with Major Depressive Disorder. *Clin Psychopharmacol Neurosci*. **15**, 361–368 <https://doi.org/10.9758/cpn.2017.15.4.361> (2017).
16. Park, J. H., Lee, Y. S., Sohn, J. H. & Han, D. H. Effectiveness of atomoxetine and methylphenidate for problematic online gaming in adolescents with attention deficit hyperactivity disorder. *Hum Psychopharmacol*. **31**, 427–432 <https://doi.org/10.1002/hup.2559> (2016).
17. Zajac, K., Ginley, M. K., Chang, R. & Petry, N. M. Treatments for Internet gaming disorder and Internet addiction: A systematic review. *Psychol. Addict. Behav.* **31**, 979–994 <https://doi.org/10.1037/adb0000315> (2017).
18. King, D. L. *et al.* Treatment of Internet gaming disorder: An international systematic review and CONSORT evaluation. *Clin. Psychol. Rev.* **54**, 123–133 <https://doi.org/10.1016/j.cpr.2017.04.002> (2017).
19. Chambless, D. L. & Hollon, S. D. Defining empirically supported therapies. *J. Consult. Clin. Psychol.* **66**, 7–18 (1998).
20. Winkler, A., Dorsing, B., Rief, W., Shen, Y. & Glombiewski, J. A. Treatment of internet addiction: a meta-analysis. *Clin. Psychol. Rev.* **33**, 317–329 <https://doi.org/10.1016/j.cpr.2012.12.005> (2013).
21. Furukawa, T. A., Cipriani, A., Barbui, C., Brambilla, P. & Watanabe, N. Imputing response rates from means and standard deviations in meta-analyses. *Int. Clin. Psychopharmacol.* **20**, 49–52 (2005).
22. Young, K. S. Caught in the net: How to recognize the signs of internet addiction and a winning strategy for recovery(1998).
23. Laconi, S., Rodgers, R. F. & Chabrol, H. The measurement of Internet addiction: A critical review of existing scales and their psychometric properties. *Computers in Human Behavior*. **41**, 190–202 (2014).
24. Bangdiwala, S. I. *et al.* Statistical methodologies to pool across multiple intervention studies. *Transl. Behav. Med.* **6**, 228–235 <https://doi.org/10.1007/s13142-016-0386-8> (2016).
25. Wang, R. & Ware, J. H. Detecting moderator effects using subgroup analyses. *Prevention science: the official journal of the Society for Prevention Research*. **14**, 111–120 <https://doi.org/10.1007/s11121-011-0221-x> (2013).
26. Baker, W. L. *et al.* Understanding heterogeneity in meta-analysis: the role of meta-regression. *Int. J. Clin. Pract.* **63**, 1426–1434 <https://doi.org/10.1111/j.1742-1241.2009.02168.x> (2009).
27. Kuss, D. J. & Lopez-Fernandez, O. Internet addiction and problematic Internet use: A systematic review of clinical research. *World J Psychiatry*. **6**, 143–176 <https://doi.org/10.5498/wjp.v6.i1.143> (2016).
28. Guessoum, S. B. *et al.* Adolescent psychiatric disorders during the COVID-19 pandemic and lockdown. *Psychiatry Res.* **291**, 113264 <https://doi.org/10.1016/j.psychres.2020.113264> (2020).
29. Kuss, D. J. & Griffiths, M. D. Internet and gaming addiction: a systematic literature review of neuroimaging studies. *Brain sciences*. **2**, 347–374 <https://doi.org/10.3390/brainsci2030347> (2012).
30. Sepede, G. *et al.* Functional magnetic resonance imaging of internet addiction in young adults. *World J Radiol.* **8**, 210–225 <https://doi.org/10.4329/wjr.v8.i2.210> (2016).
31. Rumpf, H. J. *et al.* Including gaming disorder in the ICD-11: The need to do so from a clinical and public health perspective. *Journal of behavioral addictions*. 1–6 <https://doi.org/10.1556/2006.7.2018.59> (2018).
32. Koo, C., Wati, Y., Lee, C. C. & Oh, H. Y. Internet-addicted kids and South Korean government efforts: boot-camp case. *Cyberpsychol Behav Soc Netw.* **14**, 391–394 <https://doi.org/10.1089/cyber.2009.0331> (2011).
33. Throuvala, M. A., Griffiths, M. D., Rennoldson, M. & Kuss, D. J. School-based Prevention for Adolescent Internet Addiction: Prevention is the Key. A Systematic Literature Review. *Curr. Neuropharmacol.* <https://doi.org/10.2174/1570159X16666180813153806> (2018).

Supplementary Tables

The supplementary table S1 is not available with this version.

Figures

Figure 1

Meta-regression plot, $\tau^2 = 1.209$, $I^2_{\text{Residual}} = 90.32\%$, $\text{Adjusted_R}^2 = 14.65\%$, $n=207$.

Figure 2

Meta-regression plot, $\tau^2 = 1.188$, $I^2_{\text{Residual}} = 89.74\%$, $\text{Adjusted_R}^2 = 16.10\%$, $n=207$.

Figure 3

Funnel plots for treatment effects of children and adolescents with Internet addiction. The Egger's regression intercept testing for bias was significant.