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The Intersection of Internet Gaming Disorder and Attention-Deficit/Hyperactivity Disorder Among Children and Adolescents: A Review of Literature

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Abstract

The present literature review aims to explore the relationship between internet gaming disorder (IGD) and attention-deficit hyperactivity disorder (ADHD) in children and adolescents. The paper is based on a literature search using PubMed, ResearchGate, MDPI, and Google Scholar. This review included examinations of IGD and ADHD among children and adolescents separately and bi-directionally. Current trends and data indicate a consistent increase in correlations between IGD and ADHD among children and adolescents, particularly in impulsivity and behavioral disturbance symptoms. While these results have implications for all professionals working with children and adolescents, special attention is given to clinical mental health professionals. The review concludes by highlighting the need for continued research into developing a universally accepted, valid, and reliable measure for diagnosing IGD and further studies to ascertain potential bi-directionality with ADHD among children and adolescents.

Keywords: internet gaming disorder, attention-deficit/hyperactivity disorder, children, adolescents

The Intersection of Internet Gaming Disorder and ADHD Among Children and Adolescents: A Review of Literature

According to the Entertainment Software Association (2022), 71 percent of individuals under the age of 18 play video games regularly. Video games have generally been subdivided into six groups: creative, educational, and violent/non-violent character-based and non-character-based (Masi et al., 2021). While there are a variety of groups of video games, more research is warranted to ascertain the impact of the types of video games on children and adolescents, particularly with the rise in popularity of time-consuming massively multiplayer online role-playing games (MMORPG) and multiplayer online battle arena (MOBA) games. Could problematic video game use be connected to an increase in attention-deficit/hyperactivity disorder (ADHD) symptoms? The purpose of this paper is to review the literature and explore the relationship (e.g., diagnostic, neural, behavioral, etc.) between internet gaming disorder (IGD) and ADHD in children and adolescents.

Diagnostic

The International Classification of Diseases (ICD-11; 2018) included gaming disorder in its most recent revision. Likewise, IGD was included in the *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition, Text Revision (DSM-5-TR) as a condition necessitating further clinical research (American Psychological Association, 2022). The World Health Organization (2018) outlined three criteria for determining gaming disorder: impaired control over gaming, increased priority given to gaming, and continuation of gaming despite negative consequences. As with other addictions, the DSM-5 proposed diagnosis for IGD requires five or more of the following symptoms within a year: preoccupation or obsession, withdrawal symptoms when gaming is taken away, increased tolerance, inability to give up playing, loss of interest in other

enjoyable activities, continuing to game despite problems, deception related to playing time, continued use despite risks and negative consequences, and the use of gaming to relieve negative moods.

ADHD is a neurobehavioral disorder divided into three subcategories: hyperactive-impulsive (ADHD/HI), inattentive (ADHD/I), and combined presentation (ADHD/C). The latter, ADHD/combined presentation, comprises symptomology of both hyperactive and inattentive. The American Psychological Association (2022) defined ADHD as a "persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning and development." ADHD often impacts multiple areas of an individual's life, including executive and social functioning, and is often co-occurring with other disorders, such as anxiety and oppositional defiant disorder.

Research has indicated that addiction disorders, including substance use disorder (SUD), are more prevalent among individuals diagnosed with ADHD. In a study conducted by Howard et al. (2020), a diagnosis of ADHD in childhood predicted increased early substance use risk and thereby, after age 17, more frequent use of every substance. Their results also found that 68.8% of ADHD individuals had early involvement with more than one substance, contrasted with 51% of normative control group individuals. In exploring the relationship between ADHD and substance use, Zulauf et al. (2014) concluded that ADHD children and adolescents are at an increased risk of developing early-onset substance use disorders. Similarly, an earlier report by Wilens (2007) found that “there is a clinical and statistical bidirectional overlap of ADHD and SUD” (p. 7). Molina and Pelham (2003) provided further delineation in their longitudinal study of 142 ADHD children and 100 non-ADHD children into adolescence (13-18 years old). The authors utilized bivariate analyses of selected childhood predictors and found that inattentiveness

predicted substance use in seven of nine tests while impulsivity and hyperactivity in only two of the nine tests. Additionally, when utilizing multivariate analyses, inattention in childhood remained statistically significant in their results.

Symptoms

Previous findings have indicated that IGD is a complex disorder that may be brought on by many factors, including poor decision-making, low self-esteem, and impulsivity (Paulus et al., 2018). Lee et al. (2016) reported that past empirical evidence indicates that impulsivity, as experienced in two subtypes of ADHD, may also act as a risk factor for IGD. In a landmark cross-sectional analysis of video games and ADHD symptoms in adolescents, Chan and Rabinowitz (2006) found an increase in ADHD and inattention symptoms in adolescents who play video games for more than an hour a day. Fifteen years later, in a study conducted among ADHD and non-ADHD children aged 4-12 years, the researchers found a significant correlation between ADHD symptoms of impulsivity, inattention, and hyperactivity and video game addiction, with the strongest correlation with impulsivity (Masi et al., 2021). The authors reported no significant association between time spent playing video games and hyperactivity, but further study is needed to more clearly understand the correlation between ADHD and video game use (Chan & Rabinowitz, 2006).

Hyperactivity, inattention, and self-esteem problems play an essential role in the adolescent development of IGD. In a cross-sectional one-year longitudinal study, Wartberg et al. (2018) found that IGD may contribute to emotional distress and mental health deterioration in a sample of 985 adolescent participants. The researchers also discovered hyperactivity/inattention and self-esteem problems seem to play an important role in the development of IGD in adolescence. These results could be taken into account in the development of preventive

approaches, and furthermore, the findings imply that it could be promising to consider psychological comorbidities in interventions for IGD.

Utilizing the Internet Addiction Test (IAT), Berloffa et al. (2022) discovered twice as many ADHD patients scored above the cutoff for IGD as a control group, 42.1% to 20.4% respectively, with higher IAT scores correlating with more significant inattention and hyperactivity. In addition, they found that 48 of 108 ADHD subjects met the criteria for gaming disorder as compared to 14 out of 147 control subjects when administering the Internet Gaming Disorder Scale Short-Form (IGDS9-SF), and ADHD subjects demonstrated more significant functional impairment, inattention, and hyperactivity. Table 1 summarizes assessment tools and findings of studies among adolescents in which there were significant differences between behavioral issues, emotional dysregulation, and potential co-morbidity of ADHD and IGD. Sample sizes, geographic locations, and statistical methods (e.g., correlations, logistic regressions, ANOVAs, etc.) varied among the studies, but results showed statistically significant findings between the two disorders.

Insert Table 1

Neural

As part of the brain's reward system, dopamine is a neurotransmitter that helps regulate mood, motivation, and pleasure. Weiss et al. (2011) found that the high stimulation of video games is designed with incentives to advance to additional levels and lead to increased vulnerability of ADHD individuals to develop addictive behaviors. Similar results were reported by Koepp et al. (1998), who found an increase striatal dopamine release activating the reward pathway in people with ADHD when playing video games. Potential duality was offered by Gentile et al. (2012), who hypothesized that the design of video games to be exciting leads to

other activities seeming less interesting and alters an individual's expectation related to excitement stimulation. This distortion, along with the sensation-seeking nature of ADHD, can increase an individual's time spent playing video games and contribute to loss of control in mitigating the negative consequences of prolonged video game play. These findings were consistent with those put forth by Masi et al. (2021), who postulated that the "success of massively multiplayer online role-playing games … followed by other games that increased reinforcement levels while creating a potentially higher risk of developing excessive use" (p. 7).

A comparison of ADHD, ADHD+IGD, and non-ADHD adolescents using quantitative electroencephalography (QEEG) found that co-morbidity of ADHD and IGD indicates an increase within the right medial parieto-occipital and temporal regions of the brain (Park et al., 2017). Park et al. (2017) suggested that this increased neuronal connectivity may result from repetitive activation of the dopaminergic brain reward and working memory systems associated with continuous gaming stimulus. Another study found that compared to healthy controls, at baseline, both ADHD and IGD individuals exhibited reduced brain functional connectivity from both the right-middle front gyrus and the left cingulate to the caudate (Han et al., 2021). Abnormal increases have also been observed in "some structural connections within circuitry pertaining to inhibitory function or sensory integration" (Kim et al., 2020). Fractional anisotropy (FA) values in patients assessed with co-morbid ADHD and IGD provide a neurobiological underpinning to understand the effect of altered inhibitory function and aberrant visual and spatial integration on the severity of symptoms. Implications related to a more different symptomatic association in ADHD individuals could be inferred from these findings as the association in more distinct. In doing so, the results may help explain the importance of

comorbidity when treating or evaluating clients with internet gaming or ADHD (Kim et al., 2020).

Du et al. (2016) found correlations between the Barrett Impulsiveness Scale (BIS) score and gray matter volume in specific brain areas associated with attention and emotional regulation. Behavior inhibition was also decreased in IGD+ adolescent males demonstrating a potential contribution to impulse control problems (Du et al., 2016). Gao et al. (2021) also discovered structural and functional brain abnormalities, including lower gray matter volume in the prefrontal cortex in both ADHD and IGD, indicating a potential link between the conditions and emotional dysregulation and poor self-control.

Behavioral

Historically, males have been diagnosed with ADHD at a ratio of 2:1 in comparison with females. Nikkelen et al. (2014) suggested that males may be more susceptible to the effect of screen media on ADHD behaviors. Past research indicates that males are more susceptible to the effects of violent media due to a tendency to exhibit more physical aggression (Beyens et al., 2018). Tzang et al. (2022) found that children and adolescents with ADHD and IGD co-morbidity had a greater risk of disruptive mood dysregulation. These findings are congruent with results from a study using the Child Behavior Checklist (CBCL) for ages 6-18 that showed ADHD patients scoring higher than non-ADHD patients in internalizing and externalizing problems and on the CBCL subscale for rule-breaking behavior (Berloffa et al., 2022).

Emotional Dysregulation

Van Stralen (2016) identifies emotional dysregulation as highly prevalent and a key feature of ADHD. During a neurological brain mapping study, fMRI brain scans indicated that ADHD children exhibit significantly more aggressive responses when battling fictitious

opponents than non-ADHD children (Weissenberger et al., 2016). Chang et al. (2020) posited that mood dysregulation can also be activated when ADHD youth with gaming addiction experience withdrawal symptoms. Based on these indications, considerations need to be made to differentiate between gaming disorder withdrawal symptoms and real disruptive mood dysregulation disorder (DMDD; Tzang et al., 2022).

Berloffa et al. (2022) reported that individuals presenting with externalizing problems, including rule-breaking behaviors and aggression, may represent a specific phenotype of co-morbid ADHD and IGD individuals. Overlapping ADHD and IGD symptoms, including behavioral disturbances, can contribute to difficulty in identifying the source of mood dysregulation. To this end, Tzang et al. (2022) conducted a study to examine the potential correlation between gaming disorder, untreated ADHD, and DMDD. Congruent with the research domain criteria model perspective, their results indicated that the negative emotional symptoms of ADHD may be aggravated by gaming disorder and lead to emotional dysregulation (Tzang et al., 2022). Similar results were found in an earlier study indicating that ADHD children exhibit significantly higher levels of emotional dysregulation (Seymour et al., 2012). Semrud-Clikeman et al. (2010) provided additional delineation as their results found that children with the combined presentation of ADHD demonstrated more difficulty with emotional control and behavioral regulation than those with predominately inattentive ADHD.

The heterogeneity of ADHD contributes to difficulty ascertaining if the emotional intensity symptoms associated with ADHD lead to emotional dysregulation or if emotional dysregulation exacerbates ADHD symptoms. Further blurring the distinction is a study completed by Musser et al. (2013), which followed up on their earlier study in 2011 and found differences in the amount of activity in the sympathetic and parasympathetic nervous symptoms

among two groups of children diagnosed with ADHD and a community group. The ADHD individuals with baseline prosocial behavior exhibited elevated parasympathetic reactivity with respiratory sinus arrhythmia (RSA). RSA refers to the naturally occurring variability in interbeat intervals of the heart across the respiratory cycle. It is an indicator of parasympathetic nervous system (PNS) activity that indexes an individual's capacity to regulate emotions in response to stress (Beauchaine, 2001; Porges, 1995; 2007). Musser and colleagues (2013) demonstrated increased sympathetic activity compared to those with low prosocial behavior who exhibited reduced activity in both systems. In 2020, Morris et al. replicated and extended the earlier study of Musser et al. (2013) and found similar results with some differences. ADHD youth in the latter study were found to have emotional regulation difficulties during emotionally evocative situations, but the researchers attributed differences in the RSA augmentation to the original study participants being from a community sample while their participants were from a clinical sample (Morris et al., 2020). Because participants are often selected based on convenience for researchers, there are limitations in ascribing emotional dysregulation to ADHD or IGD. Additional variables, including parental structure, community stressors, academic pressures, and socioeconomic status, can contribute to emotional dysregulation in youth.

Social

Multiplayer video games have increased the availability of socialization through digital means while playing video games, but traditional video games have been designed to allow for single-player use. Associations have been found between low psychological well-being, including low social competence and loneliness, and pathological gaming (Khazaal et al., 2016; Lemmens et al., 2011). A cross-sectional study among 102 children and adolescents with a mean age of 11.6 found that youth with co-morbid ADHD and IGD exhibited more conflictual and

withdrawal tendencies than peers with a sole diagnosis of ADHD. The study also indicated poorer interpersonal relationships with more time spent gaming and chatting online during weekdays and weekends (Chang et al., 2021). ADHD youth with internet addiction, including gaming disorder, were characterized as having significantly poor interpersonal relationships compared to non-addicted peers in other studies (Chang et al., 2020; Tzang et al., 2022).

Individuals with the inattentive subtype of ADHD appear to exhibit impaired social functioning, including deficits in social knowledge and social passivity (Wheeler Maedgen & Carlson, 2000). Chang et al. (2020) also found that IGD could be a potential means to avoid social interaction, but "longer playing time featuring aggressive content may also aggravate an underlying mental disorder through a long process of social interaction deprivation or stimulation deprivation" (p. 354). This study is supported by André et al. (2020), who found that highly engaged gamers experienced more frequent feelings of loneliness, and the probability of problematic and addictive gaming could be mitigated by having enough friends. Research findings by Tzang et al. (2022) also indicated that social isolation related to the COVID-19 pandemic contributed to increased dysregulated mood due to excessive gaming behaviors.

Gaming Time

Individuals with problematic gaming behavior often spend much of their available leisure time at the expense of other activities, including socialization with peers. The lack of participation in other activities, such as sports and school clubs, can lead to socialization difficulties and other detrimental effects. In a 2-year longitudinal study, Jeong et al. (2020) found that non-cases of individuals at high risk for IGD (HIGD) at baseline were more likely to increase their IGD severity scores based on the amount of time spent playing online games. Their results indicated that individuals playing for 1-4 hours per day on weekdays were 1.38 times

more likely to increase their scores. This figure increased to 1.71 for individuals who spent more than four hours per day compared to similar baseline peers who spent less than 60 minutes per day on online games (Jeong et al., 2020). Masi et al. (2021) found that ADHD children exhibited prolonged periods of video game use and observed a correlation between the excessive use of video games and the severity of ADHD symptoms. Similarly, Jeong et al. (2020) found that adolescents with ADHD symptoms were 1.40x more likely to increase their IGD severity scores over time. High involvement in video games was also correlated with a decrease in student academic achievement (Haghbin et al., 2013).

Gender Considerations

Masi et al. (2021) found that ADHD males had the highest addiction scores compared to females and non-ADHD children. Among males in general, similar results were reported by Phan et al. (2019), who found that 20% of male adolescents scored above the threshold for IGD compared to 7% of adolescent females. Phan et al. (2019) also found differences associated with quality of life, as males over the age of 15 reported the most significant decrease in quality related to the effect of IGD symptoms. While females in the study reported lower satisfaction of life and more depression than IGD+ males at baseline, there was no significant association for females between the quality of life and IGD as compared to male peers under and over the same age (Phan et al., 2019). These results could be attributed to the types of games that typically appeal to each gender based on societal expectations of gender behavior.

Societal viewpoints on gender roles have the potential to highlight IGD among females as they are often underrepresented in studies despite 2022 Entertainment Software Association statistics reporting almost half of video game players are females. Leonhardt and Overå (2021) hypothesized that the prevalence of IGD among males could be attributed to cultural roles and

expectations reflected in video game design and content being geared toward males. Mackinnon et al. (2017) found that behavioral addictions are markedly greater in individualistic cultures that value autonomy and in which social connections can be altered by self-focus that contributes to increased competitiveness. These findings may support expected gender differences within American culture that males are more competitive and play violent-type video games. In contrast, females are more likely to utilize social media to seek emotional connections with others (Marraudino et al., 2022).

Discussion

Adolescence is a high-risk addiction period among young ADHD individuals (Ginsberg, 2014; Masi et al., 2021). While depression and anxiety may be associated with internet addiction in general, Ko et al. (2009) showed that ADHD is the strongest predictor. Chang et al. (2020) supported these findings and found that the co-morbidity of IGD based on DSM-5 criteria was 51.5% among youth with ADHD. This figure was an astonishing 83% in a study conducted by Bozhurt et al. (2013). In a study conducted by Razjouyan et al. (2020) investigating the frequency of addiction to video games, 11% of children with ADHD had an addiction to video games as compared to 4% of children without ADHD.

Studies conducted among youth to investigate the relationship between ADHD and IGD have disproportionately been with male subjects. Literature indicates that males have higher incidences of hyperactivity, impulsivity, and aggression associated with ADHD, and females are more likely to exhibit inattentiveness. Conclusions can be drawn that males are more drawn to video games while females have higher rates of social media use. Research conducted by Menendez-Garcia et al. (2020) among 112 patients aged 7-17 (51 diagnosed with ADHD, 61 without ADHD diagnosis) supported this conclusion as researchers found that IGD was

associated with ADHD/HI and ADHD/C and mobile phone addiction with ADHD/I. Further research is needed to accurately assess the prevalence of IGD among females due to limitations in available research.

Research may indicate a bidirectional relationship between IGD and ADHD based on presented evidence of co-morbidity and susceptibility of individuals with ADHD to develop IGD. Masi et al. (2021) conclude that this bi-directionality could be attributed to the symptomology of ADHD causing greater appeal of video games, while video game play reinforces the need for instant gratification that exacerbates ADHD symptoms. Potential bidirectional causality between video game playing and impulsivity and attention problems was also indicated in an earlier study by Gentile et al. (2012) based on video game exposure. Beyens et al. (2018) suggested that "children high in ADHD-related behaviors may therefore be more likely to choose violent or otherwise arousing media which may, in turn, increase their ADHD-related behaviors" (p. 9878).

Limitations persist in identifying IGD as there needs to be a consensus on a designated reliability and validity assessment tool in diagnosing gaming disorder (see Table 1). A sample of 1003 gamers from 57 different countries assessed using confirmatory factor analysis supported the viability of the IGD-20 Test with a six-factor structure based on nine criteria proposed in the DSM-5-TR. This research is not without its limitations, as the researchers offer caution in interpreting results in generalizability and may only represent some gamers (Pontes et al., 2014). Inconsistency in the prevalence of co-morbidity of ADHD and IGD may be attributed to the variances in assessment tools utilized to determine the potential diagnosis and severity of gaming disorder.

There is also inconsistency in the consensus on the classification of IGD. Research from multiple studies discussed in this review indicates that a unifying factor is increased impulsivity related to co-morbid ADHD and IGD. These results support the argument that gaming disorder should be classified as an impulse control disorder. Because individuals with IGD have exhibited compulsivity in video game play, an argument could be made that IGD should fall under the spectrum of obsessive-compulsive disorders. Weinstein et al. (2017) posit that findings indicate a "resemblance between the neural mechanisms" (p.10) underlying gaming disorder and substance use disorders, including tolerance, withdrawal, excessive use despite adverse consequences, and loss of control and inhibition. Other researchers' supposition supports the behavioral addiction model to classify IGD as a behavioral addiction alongside other addictive disorders based on research linking dopamine receptors and results of fMRI studies (Kuss et al., 2018).

Conclusion

ADHD and IGD are complex disorders that can cause significant dysfunction in multiple domains of an individual's life, including family, social, academic, and executive functioning. Both disorders can be characterized by impulsivity, emotional dysregulation, and isolative behaviors. Studies have attempted to examine a potential bidirectional relationship between the two disorders, including effects on neural activity and structural changes within the brain. Research presented within this literature review supports a bidirectional relationship. However, limited research, along with a lack of consensus on classifying and assessing for IGD, is indicative that future research should include reliability and validity testing on assessment tools. Future research should also focus on replicating studies in differing genders and cultural contexts to assess for generalizability of reported findings.

References

American Psychiatric Association. (2022). *Diagnostic and Statistical Manual of Mental Disorders, Text Revision Dsm-5-tr* (5th ed.). Amer Psychiatric Pub Inc.

André, F., Broman, N., Håkansson, A., & Claesdotter-Knutsson, E. (2020). Gaming addiction, problematic gaming and engaged gaming – prevalence and associated characteristics. *Addictive Behaviors Reports, 12,* Article 100324. https://doi.org/10.1016/j.abrep.2020.100324

Beauchaine, T. P. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology, 13,* 183–214. https://doi.org/10.1017/S0954579401002012

Berloffa, S., Salvati, A., D'Acunto, G., Fantozzi, P., Inguaggiato, E., Lenzi, F., Milone, A., Muratori, P., Pfanner, C., Ricci, F., Ruglioni, L., Tacchi, A., Tessa, C., Villafranca, A., & Masi, G. (2022). Internet gaming disorder in children and adolescents with attention deficit hyperactivity disorder. *Children*, *9*(3), 428. https://doi.org/10.3390/children9030428

Beyens, I., Valkenburg, P. M., & Piotrowski, J. T. (2018). Screen media use and ADHD-related behaviors: Four decades of research. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(40), 9875–9881. https://doi.org/10.1073/pnas.1611611114

Bozkurt, H., Coskun, M., Ayaydin, H., Adak, I., & Zoroglu, S. S. (2013). Prevalence and patterns of psychiatric disorders in referred adolescents with Internet addiction.

Psychiatry and Clinical Neurosciences, *67*(5), 352–359. https://doi.org/10.1111/pcn.12065

Chan, P. A., & Rabinowitz, T. (2006). A cross-sectional analysis of video games and attention deficit hyperactivity disorder symptoms in adolescents. *Annals of General Psychiatry*, 5(1), 16–16. https://doi.org/10.1186/1744-859X-5-16

Chang, C. H., Chang, Y. C., Cheng, H., & Tzang, R. F. (2020). Treatment efficacy of internet gaming disorder with attention deficit hyperactivity disorder and emotional dysregulation. *The International Journal of Neuropsychopharmacology*, *23*(6), 349–355. https://doi.org/10.1093/ijnp/pyaa010

Chang, Y.-C., & Tzang, R.-F. (2021). Proposing and validating the diagnosis scale for internet gaming disorder in Taiwanese ADHD adolescents: Likert scale method based on the DSM-5. *International Journal of Environmental Research and Public Health*, *18*(4), 1492–. https://doi.org/10.3390/ijerph18041492

Du, X., Qi, X., Yang, Y., Du, G., Gao, P., Zhang, Y., Qin, W., Li, X., & Zhang, Q. (2016). Altered structural correlates of impulsivity in adolescents with internet gaming disorder. *Frontiers in Human Neuroscience*, 10, 4–4. https://doi.org/10.3389/fnhum.2016.00004

Gaming disorder. (n.d.). Retrieved October 22, 2022, from https://www.who.int/standards/classifications/frequently-asked-questions/gaming-disorder

Gao, X., Zhang, M., Yang, Z., Wen, M., Huang, H., Zheng, R., Wang, W., Wei, Y., Cheng, J., Han, S., & Zhang, Y. (2021). Structural and functional brain abnormalities in internet gaming disorder and attention-deficit/hyperactivity disorder: A comparative meta-analysis. *Frontiers in Psychiatry*, *12*, 679437. https://doi.org/10.3389/fpsyt.2021.679437

Gentile, D. A., Swing, E. L., Lim, C. G., & Khoo, A. (2012). Video game playing, attention problems, and impulsiveness: Evidence of bidirectional causality. *Psychology of Popular Media Culture, 1*(1), 62–70. https://doi.org/10.1037/a0026969

Ginsberg, Y., Beusterien, K. M., Amos, K., Jousselin, C., & Asherson, P. (2014). The unmet needs of all adults with ADHD are not the same: A focus on Europe. *Expert Review of Neurotherapeutics*, *14*(7), 799–812. https://doi.org/10.1586/14737175.2014.926220

Han, D. H., Kim, S. M., Bae, S., Renshaw, P. F., & Anderson, J. S. (2017). Brain connectivity and psychiatric co-morbidity in adolescents with Internet gaming disorder. *Addiction Biology*, *22*(3), 802–812. https://doi.org/10.1111/adb.12347

Haghbin, M., Shaterian, F., Hosseinzadeh, D., & Griffiths, M. D. (2013). A brief report on the relationship between self-control, video game addiction and academic achievement in normal and ADHD students. *Journal of Behavioral Addictions*, *2*(4), 239–243. https://doi.org/10.1556/JBA.2.2013.4.7

Howard, A. L., Kennedy, T. M., Mitchell, J. T., Sibley, M. H., Hinshaw, S. P., Arnold, L. E., Roy, A., Stehli, A., Swanson, J. M., & Molina, B. S. G. (2020). Early substance use in the pathway from childhood attention-deficit/hyperactivity disorder (ADHD) to young adult substance use: Evidence of statistical mediation and substance specificity. *Psychology of Addictive Behaviors*, *34*(2), 281–292. https://doi.org/10.1037/adb0000542

Jeong, H., Yim, H. W., Lee, S. Y., Lee, H. K., Potenza, M. N., & Lee, H. (2021). Factors associated with severity, incidence or persistence of internet gaming disorder in children and adolescents: a 2-year longitudinal study. *Addiction (Abingdon, England)*, *116*(7), 1828–1838. https://doi.org/10.1111/add.15366

Khazaal, Y., Chatton, A., Rothen, S., Achab, S., Thorens, G., Zullino, D., & Gmel, G. (2016). Psychometric properties of the 7-item game addiction scale among French and German speaking adults. *BMC Psychiatry*, *16*, 132. https://doi.org/10.1186/s12888-016-0836-3

Kim, M., Kim, D., Bae, S., Han, D. H., & Jeong, B. (2020). An aberrant structural network of co-morbid attention-deficit/hyperactivity disorder is associated with addiction severity in internet gaming disorder. *NeuroImage. Clinical*, *27*, 102263. https://doi.org/10.1016/j.nicl.2020.102263

Ko C.-H., Yen J.-Y., Chen C.-S., Yeh Y.-C., & Yen C.-F. (2009). Predictive values of psychiatric symptoms for internet addiction in adolescents: A 2-Year prospective study. *Archives of Pediatrics & Adolescent Medicine*, *163*(10), 937–943. https://doi.org/10.1001/archpediatrics.2009.159

Kuss, D. J., Pontes, H. M., & Griffiths, M. D. (2018). Neurobiological correlates in internet gaming disorder: A systematic literature review. *Frontiers in Psychiatry*, 9, 166–166. https://doi.org/10.3389/fpsyt.2018.00166

Lee, S. Y., Lee, H. K., & Choo, H. (2017). Typology of internet gaming disorder and its clinical implications. *Psychiatry and Clinical Neurosciences*, *71*(7), 479–491. https://doi.org/10.1111/pcn.12457

Leonhardt, M., & Overå, S. (2021). Are there differences in video gaming and use of social media among boys and girls?—A mixed methods approach. *International Journal of Environmental Research and Public Health*, *18*(11), 6085. https://doi.org/10.3390/ijerph18116085

Mackinnon, S., Couture, M., Cooper, M., Kuntsche, E., O'Connor, R., & Stewart, S. (2017). Cross-cultural comparisons of drinking motives in 10 countries: Data from the DRINC project. *Drug and Alcohol Review*, *36*(6), 721–730. https://doi.org/10.1111/dar.12464

Marraudino, M., Bonaldo, B., Vitiello, B., Bergui, G. C., & Panzica, G. (2022). Sexual differences in internet gaming disorder (IGD): From psychological features to neuroanatomical networks. *Journal of Clinical Medicine*, *11*(4), 1018. https://doi.org/10.3390/jcm11041018

Masi, L., Abadie, P., Herba, C., Emond, M., Gingras, M. P., & Amor, L. B. (2021). Video games in ADHD and non-ADHD Children: Modalities of use and association with ADHD symptoms. *Frontiers in Pediatrics*, *9*, 632272. https://doi.org/10.3389/fped.2021.632272

Menéndez-García, A., Jiménez-Arroyo, A., Rodrigo-Yanguas, M., Marin-Vila, M., Sánchez-Sánchez, F., Roman-Riechmann, E., & Blasco-Fontecilla, H. (2022). Internet, video game and mobile phone addiction in children and adolescents diagnosed with ADHD: A case-control study. Adicción a Internet, videojuegos y teléfonos móviles en niños y adolescentes: Un estudio de casos y controles. *Adicciones*, *34*(3), 208–217. https://doi.org/10.20882/adicciones.1469

Molina, B.S., & Pelham, W.E. (2003). Childhood predictors of adolescent substance use in a longitudinal study of children with ADHD. *Journal of Abnormal Psychology*, *112*(3), 497-507.

Morris, S., Musser, E. D., Tenenbaum, R. B., Ward, A. R., Martinez, J., Raiker, J. S., Coles, E. K., & Riopelle, C. (2020). Emotion regulation via the autonomic nervous system in children with attention-deficit/hyperactivity disorder (ADHD): Replication and extension.

Journal of Abnormal Child Psychology, *48*(3), 361–373. https://doi.org/10.1007/s10802-019-00593-8

Musser, E. D., Galloway-Long, H. S., Frick, P. J., & Nigg, J. T. (2013). Emotion regulation and heterogeneity in attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child and Adolescent Psychiatry*, *52*(2), 163–171.e2. https://doi.org/10.1016/j.jaac.2012.11.009

Nikkelen, S. W. C., Valkenburg, P. M., Huizinga, M., & Bushman, B. J. (2014). Media use and ADHD-related behaviors in children and adolescents: A meta-analysis. *Developmental Psychology*, 50(9), 2228–2241. https://doi.org/10.1037/a0037318

Park, J. H., Hong, J. S., Han, D. H., Min, K. J., Lee, Y. S., Kee, B. S., & Kim, S. M. (2017). Comparison of QEEG findings between adolescents with attention deficit hyperactivity disorder (ADHD) without co-morbidity and ADHD co-morbid with internet gaming disorder. *Journal of Korean Medical Science*, *32*(3), 514–521. https://doi.org/10.3346/jkms.2017.32.3.514

Paulus, F. W., Sinzig, J., Mayer, H., Weber, M., & von Gontard, A. (2018). Computer gaming disorder and ADHD in young children—a population-based study. *International Journal of Mental Health and Addiction*, 16(5), 1193–1207. https://doi.org/10.1007/s11469-017-9841-0

Phan, O., Prieur, C., Bonnaire, C., & Obradovic, I. (2019). Internet gaming disorder: Exploring its impact on satisfaction in life in PELLEAS adolescent sample. *International Journal of Environmental Research and Public Health*, *17*(1), 3. https://doi.org/10.3390/ijerph17010003

Pontes, H. M., Király, O., Demetrovics, Z., & Griffiths, M. D. (2014). The conceptualisation and measurement of DSM-5 internet gaming disorder: The development of the IGD-20 test. *PloS One*, *9*(10), e110137. https://doi.org/10.1371/journal.pone.0110137

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage: A polyvagal perspective. *Psychophysiology*, *32*, 301–318. https://doi.org/10.1111/j.1469-8986.1995.tb01213.x

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology*, *74*, 116–143. https://doi.org/10.1016/j.biopsycho.2006.06.009

Razjouyan, K., Khademi, M., Dorandish, Z. Y., & Davari-Ashtiani, R. (2020). An investigation into the frequency of addiction to video games in children with attention-deficit hyperactivity disorder. *Journal of Family Medicine and Primary Care*, *9*(2), 669–672. https://doi.org/10.4103/jfmpc.jfmpc_464_19

Salerno, L., Becheri, L., & Pallanti, S. (2022). ADHD-gaming disorder co-morbidity in children and adolescents: A narrative review. *Children (Basel)*, 9(10). https://doi.org/10.3390/children9101528

Semrud-Clikeman, M., Walkowiak, J., Wilkinson, A., & Butcher, B. (2010). Executive functioning in children with Asperger syndrome, ADHD-combined type, ADHD-predominately inattentive type, and controls. *Journal of Autism and Developmental Disorders*, *40*(8), 1017–1027. https://doi.org/10.1007/s10803-010-0951-9

Seymour, K. E., Chronis-Tuscano, A., Halldorsdottir, T., Stupica, B., Owens, K., & Sacks, T. (2012). Emotion regulation mediates the relationship between ADHD and depressive symptoms in youth. *Journal of Abnormal Child Psychology*, *40*(4), 595–606. https://doi.org/10.1007/s10802-011-9593-4

Stavropoulos, V., Adams, B., Beard, C. L., Dumble, E., Trawley, S., Gomez, R., & Pontes, H. M. (2019). Associations between attention deficit hyperactivity and internet gaming disorder symptoms: Is there consistency across types of symptoms, gender and countries? *Addictive Behaviors Reports*, *9*, 100158. https://doi.org/10.1016/j.abrep.2018.100158

2022 Essential Facts About the Video Game Industry. (2022, June 7). Entertainment Software Association. https://www.theesa.com/resource/2022-essential-facts-about-the-video-game-industry/

Tzang, R. F., Chang, C. H., & Chang, Y. C. (2022). Structural equation modeling (SEM): Gaming disorder leading untreated attention-deficit/hyperactivity disorder to disruptive mood dysregulation. *International Journal of Environmental Research and Public Health*, *19*(11), 6648. https://doi.org/10.3390/ijerph19116648

van Stralen J. (2016). Emotional dysregulation in children with attention-deficit/hyperactivity disorder. *Attention Deficit and Hyperactivity Disorders*, *8*(4), 175–187. https://doi.org/10.1007/s12402-016-0199-0

Wartberg, L., Kriston, L., Zieglmeier, M., Lincoln, T., & Kammerl, R. (2019). A longitudinal study on psychosocial causes and consequences of Internet gaming disorder in adolescence. *Psychological Medicine*, *49*(2), 287–294. https://doi.org/10.1017/S003329171800082X

Weinstein, A., & Weizman, A. (2012). Emerging association between addictive gaming and attention-deficit/hyperactivity disorder. *Current Psychiatry Reports*, *14*(5), 590–597. https://doi.org/10.1007/s11920-012-0311-x

Weinstein, A. M. (2017). An update overview on brain imaging studies of internet gaming disorder. *Frontiers in Psychiatry*, *8*, 185–185. https://doi.org/10.3389/fpsyt.2017.00185

Weiss, M. D., Baer, S., Allan, B. A., Saran, K., & Schibuk, H. (2011). The screens culture: impact on ADHD. *Attention Deficit and Hyperactivity Disorders*, *3*(4), 327–334. https://doi.org/10.1007/s12402-011-0065-z

Weissenberger, S., Klicperova-Baker, M., Zimbardo, P., Schonova, K., Akotia, D., Kostal, J., Goetz, M., Raboch, J., & Ptacek, R. (2016). ADHD and present hedonism: Time perspective as a potential diagnostic and therapeutic tool. *Neuropsychiatric Disease and Treatment*, *12*, 2963–2971. https://doi.org/10.2147/NDT.S116721

Wheeler Maedgen, J., & Carlson, C. L. (2000). Social functioning and emotional regulation in the attention deficit hyperactivity disorder subtypes. *Journal of Clinical Child Psychology*, *29*(1), 30–42. https://doi.org/10.1207/S15374424jccp2901_4

Wilens T. E. (2007). The nature of the relationship between attention-deficit/hyperactivity disorder and substance use. *The Journal of Clinical Psychiatry*, *68 Suppl 11*, 4–8.

Zulauf, C. A., Sprich, S. E., Safren, S. A., & Wilens, T. E. (2014). The complicated relationship between attention deficit/hyperactivity disorder and substance use disorders. *Current Psychiatry Reports*, *16*(3), 436–436. https://doi.org/10.1007/s11920-013-0436-6

Table 1

Main characteristics of reviewed IGD and ADHD studies

Authors (Year)	Sample	Age	Assessment Tool	Findings
André et al. (2020)	N=2777 (103 aged 15-18); 49.6% male; 50.1% female; 0.3% transgender	15-18; 19-24; 25-29; 30+	Gaming Addiction Scale (GAS)	Results indicated that the prevalence of addicted gamers was 1.2 percent of population Disproportionate problem gamers were gendered males Powerful correlation between problematic/addictive gaming and spending >4 hours per day on other social media
Berloffa et al. (2022)	N =255 (108 with ADHD, 147 without ADHD); Male =210; Female=45	8-18	Internet Addiction Test (IAT); Internet Gaming Disorder Scale-Short Form (IGDS9-SF); Child Behavior Checklist (CBCL); Conners' Parent Rating Scale-Revised: Short Form; Use, Abuse, Dependence to Internet (UADI)	Using parametric tests (univariate ANOVA test) and non-parametric tests (non-parametric test $\chi 2$), results indicated higher risk of IGD among ADHD patients as evidenced by presenting a two-fold IAT score and more than four-fold on the IGDS9-SF cut offs Descriptions connected with ADHD and IGD were explored using binary logistic regression models, using the IAT or IGDS9-SF cut-off as dependent variable and variables that had significant differences in the means as independent variables. Individuals with ADHD and IGD showed higher CBCL internalizing problems.
Chang et al. (2021)	N=102 children and adolescents	7-18	Chen Internet Addiction Scale (CIA); Swanson, Nolan, and Pelham, Version IV Questionnaire (SNAP-IV)	Pathological video gaming was increased in ADHD individuals IGD individuals had poorer interpersonal relationships
Du et al. (2016)	N=52 (25 children with IGD, 27 healthy controls)	Mean age = 17.28 (IGD), 17.48 (HC)	Young's Diagnostic Questionnaire for Internet Addiction; Young's Internet Addiction Scale (YIAS); Barrett's Impulsivity Scale (BIS)	Altered structural correlations to impulsivity were found in the right amygdala and left fusiform in IGD individuals

Jeong et al. (2020)	N=2319 (175 HIGD, 2144 non-cases of HIGD	3rd, 4th, 7th graders	Internet Game Use-Elicited Symptom Screen (IGUESS); Self-report online gaming survey; Children's Depressive Inventory (CDI); Trait Anxiety Inventory for Children (TAIC); Korean version ADHD Rating Scale (K-ARS)	Correlation between time spent playing video games during weekdays and increase in severity of IGD symptoms over 2-year period (>240 minutes [IRR = 1.71, 95% CI]; 60-239 minutes [IRR = 1.38, 95% CI]) Increase in adolescents with ADHD symptoms and IGD severity scores over 2-year study period
Kim et al. (2020)	N=128 males (46 IGD+/ ADHD+, 48 IGD+/ADHD-, 34 healthy controls)	No age given	Young Internet Addiction Scale (YIAS); Dupaul's ADHD scale-Korean version (K-ARS-P)	Higher YIAS score in IGD+/ADHD+ group suggesting an aberrant increase in some structural connections within circuits related to inhibitory function
Masi et al. (2021)	N= 208 children (98 in ADHD Group, 37 in Clinical-Control Group, 148 in Community-Control Group)	4-12	QUATTORD; Strengths and Difficulties Questionnaire (SDQ)	Significant Pearson correlation ($p = 0.000$; $r = 0.279$-0.310) between each ADHD symptom and video game addiction. Video game playtime and addiction were significantly higher for ADHD group compared to Community-Control group.
Phan et al. (2019)	N=2400 adolescents from schools and suburbs of Paris	12-20	Game Addiction Scale (GAS); Life Satisfaction Scale; Adolescent Depression Rating Scale (ADRS); Liebowitz Social Anxiety Scale (LSAS)	IGD+ males aged 15+ reported more significant decreased quality of life ($r = -0.405$, $p = 0.05$), no significant association with females
Razjouyan et al. (2020)	N=99 ADHD children, 99 healthy controls	No age given	Young's Internet Addiction Scale (YIAS); Conner's scale	11% of children with ADHD and 4% of healthy controls had addiction to video games
Tzang et al. (2022)	N= 102 Taiwanese ADHD children; Male=70; Female=32	7-18	Chen Internet Addiction Scale (CIAS); Swanson, Nolan, and Pelham Version IV Questionnaire (SNAP-IV)	Findings suggest that ADHD's progression to DMDD is mediated by IGD COVID-19 pandemic contributed to increased mood dysregulation among excessive gamers

Wartberg et al. (2018)	N=1095 family dyads (556 males/539 females, with relative caregiver)	12-14	Internet Gaming Disorder Scale (IGDS); Reynolds Adolescent Adjustment Screening Inventory; Strengths and Difficulties Questionnaire (SDQ)	Male gender, IGD, higher hyperactivity/inattention, and self-esteem problems were predictors of IGD one year later Baseline IGD was a predictor of emotional distress one year later
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