ADHD-Gaming Disorder Comorbidity in Children and Adolescents

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Attention Deficit/Hyperactivity Disorder (ADHD) is a neurobiological condition characterized by developmentally inadequate levels of inattention, hyperactivity, and impulsivity, and a neurobiological disruption in brain neurotransmitters and circuitry causing abnormal responses to rewards. Playing electronic games generates a biological response that activates the neuronal circuits linked to pleasure and reward, and there is a growing attention to this type of activity, which can also turn into a mental health condition. With the recognition of 'Internet Gaming Disorder' (IGD) as a condition belonging to the broader area of addiction requiring more in-depth study with respect to the DSM-5, while 'Gaming Disorder' (GD) was officially recognized as a new diagnosis by the World Health Organization (WHO) in the updated revision of the International Classification of Diseases (ICD-11).

Keywords: attention-deficit hyperactivity disorder (ADHD) ; video game ; gaming ; addiction ; children

1. Introduction

Attention Deficit/Hyperactivity Disorder (ADHD) is a neurobiological condition characterized by developmentally inadequate levels of inattention, hyperactivity, and impulsivity, causing interference with functions in several key domains in life. Epidemiological studies indicate a worldwide prevalence of ADHD in children and adolescents of 5–10% [1][2] and of 2.8% in the adult population [1]. There is accumulating evidence supporting the notion that ADHD runs in families, as family, adoption, and twin studies showed heritability estimates of 74–80%, for both males and females and for symptoms of inattention and hyperactivity–impulsivity [3][4][5].

When not adequately treated, ADHD can exert significant personal and socioeconomic burdens, determining a very deleterious impact on an individual's functioning at home, school, in social contexts, and job settings, and causing high costs on society [6]. Adolescents with ADHD are more at risk of being rejected at school, not graduating high school or college, and encountering problems in relationships with peers [7]. Moreover, they show a greater vulnerability to risk-taking behaviors than typically developing peers, including substance use disorders [8], reckless driving, and risky sexual behaviors [6][9][10]. There are several behavior scales, checklists, and clinical interviews that can aid clinicians in the ADHD evaluation process, and they are generally based on DSM-5 or ICD-11 criteria [11][12], which are aligned to enable the diagnosis of three different ADHD presentations: predominantly inattentive, predominantly hyperactive-impulsive, and combined presentations.

After the inclusion of Internet Gaming Disorder (IGD) in DSM-5 [11] as a condition requiring further study, Gaming disorder (GD) has been recently included in the updated version of the International Classification of Diseases (ICD-11; https://icd.who.int/en (accessed on 3 July 2022)) [12]. In the DSM-5, IGD was defined by a pattern of gaming resulting in significant impairment or distress that was required to meet at least five out of nine criteria, namely, preoccupation, withdrawal, tolerance, loss of control, reduced non-gaming interests, gaming in spite of harms, deception about gaming, gaming as a means to escape or to regulate mood, and conflict/interference caused by gaming [11]. Compared to IGD, ICD-11 defines GD with a stricter monothetic approach, requiring the presence of an enduring gaming behavior, a loss of control over gaming, and a functional impairment caused by gaming, represented by lost life opportunities and negative impacts on normal routines, self-care, social relationships, and responsibilities, for a 12-month period. This difference has been at the center of a vast debate and has recently provoked a panel of experts to gather to evaluate its impact on prevalence estimates and on the possible risk of pathologizing a behavior [13]. The existence of this risk was reasonable, since a multi-center cohort study performed on high-risk adolescents in Korea found a prevalence of IGD of 32.4% according to DSM-5 compared to a prevalence of 6.4% according to ICD-11 criteria [14]. Therefore, the prevalence of GD is strictly dependent on which set of diagnostic criteria the clinician refers to.

Due to the widely recognized association between ADHD and substance and behavioral addictions [6], over the past decade, there has been a proliferation of research examining the frequency of excessive internet use or gaming in people with ADHD, highlighting a frequency of their comorbidity ranging from 29% [15] to 83.3% [16].

2. Assessment of GD in ADHD

The optimal diagnostic assessment of GD is still in progress and there is a non-unanimous modality, as different studies have used different rating scales or interviews for assessing its prevalence in children and adolescents with ADHD. Among these, four studies used the Young's Internet Addiction Scale (YIAS) [17][18][19][20], three used the Chen Internet Addiction Scale (CIA) [21][22][23], two the Internet Addiction Test (IAT) [24][25], one used the Internet Gaming Disorder Interview (IGDI) [26], one the Gaming Addiction Identification Test (GAIT) [27], one the Korean Young's Internet Addiction Rating Scale (YIAS-K) [28], one the ADITEC questionnaire [29], one the Internet-Gaming Disorder Scale-Short Form (IGDS9-SF) [25], one the Game Addiction Scale for Adolescents (GASA) [30], one the Problem Video Game-Playing Test (PVGT) [31], and one the Computer and Video Game Addiction Scale [32]. Finally, one did not use any rating scales but only the criteria proposed by the DSM-5 [15], and two used reports by parents, teachers, or participants regarding the time spent gaming [33][34]. Gao and colleagues' meta-analysis included studies where the diagnosis of GD was made by using the DSM-5 criteria or the YIAS or CIAS.

3. What We Currently Know about The ADHD–GD Comorbidity

Children and adolescents with ADHD and GD have been described to be more dysfunctional video gamers, spending more time engaging in online chatting and gaming daily and during the weekends [22][34]. A different sleep pattern has also been reported, as children and adolescents with ADHD who spent more time online tended to go to sleep later at night, between 2 and 4 a.m., compared to pupils without ADHD who went to sleep between 8:30 and 10:30 p.m. [24]. However, the characteristics of the sleep pattern represent a dimension that has not been investigated by means of specific evaluation tools.

Regarding the ADHD–IGD/GD relationship, several authors reported ADHD as a risk factor for developing Internet Addiction Disorder (IAD) and IGD [25][29][30], with symptoms of ADHD having ORs of 2.43 (95% CI 1.44–4.11) to present a problematic gaming behavior [27]. Stenseng and colleagues [33] found that while ADHD predicted more time gaming, gaming behavior did not predict more ADHD symptoms, and that time spent gaming did not determine more psychiatric problems at ages 6–10. Instead, Nikkelen and colleagues [35] found that gaming may lead to more ADHD symptoms in early childhood [35] and Gentile et al. [34] described a bidirectional relationship between the time spent gaming and self-reported ADHD symptomatology in Singaporean adolescents. Moreover, they found that exposure to video game violence had a unique effect on attention problems and impulsiveness [34].

Regarding the ADHD core symptom dimensions that were most associated with GD, some authors reported a key role of impulsivity [32][35] and the association of both the combined type and predominantly hyperactive/impulsive ADHD with GD [29], whereas others found more inattentive symptoms in those with both ADHD and GD [22][31], and a trend of a clinically relevant association between the ADHD inattentive type (ADHD/I) and Mobile phone addiction (MPA), especially in females [29]. A male gender was associated with a higher rate of problematic gaming compared to girls [32][33], showing a ratio of more than 5:1, but girls showed greater overall rates of psychiatric symptoms compared to boys [27].

Children and adolescents with ADHD and IGD/GD were characterized by poor interpersonal relationships [22][23], more withdrawal tendencies, and a greater loss of control than those without GD and with more emotional problems and disruptive mood dysregulation [21][22]. GD appeared to play a mediating role in raising the risk of disruptive mood dysregulation in children and adolescents with ADHD [23]. Males were exposed to more severe consequences than females, and the negative consequences of excessive gaming were more prevalent in the social domain for males and in the emotional domain for girls [30], who appeared to be characterized by a more unstable mood and with more symptoms of depression [27].

Subjects with both ADHD and GD appeared as a heterogeneous group, with some characterized by higher internalizing problems, such as anxiety/depression, withdrawal, and socialization problems at CBCL, and others by externalizing problems and aggressive and rule-breaking behaviors [25]. Therefore, the existence of two different profiles has been hypothesized, and the two emergent profiles ("escape from reality" versus "sensation seeking") might contradistinguish diverse phenotypes of ADHD plus GD patients. Therefore, the first behavior could be interpreted as an expression of a search for pleasure in "losing control" from reality (a cardinal fingerprint of substance use disorder), while the latter as the search for exciting stimuli. Those with ADHD+GD and internalizing problems would use Internet addiction as a way to

escape from daily frustrations derived from poor self-esteem and social anxiety [25], while those with externalizing problems would be characterized by the impulsive need for rapid satisfaction.

4. The Impact of ADHD on Gaming Disorder across the Lifespan

The presence of comorbid ADHD in GD patients has been found to be associated with a poor clinical course of GD [18]. Therefore, it appears to be a pathological complication rather than as a functional coping strategy. In a 3-year clinical cohort study, although GD symptoms ameliorated over time despite comorbid ADHD, ADHD symptoms were positively associated with GD symptoms at the baseline, and changes in ADHD symptomatology were greatly associated with those in GD symptoms [18]. The patients with ADHD+GD showed a lower likelihood of recovery than the group with only GD (60% versus 93%, $p < 0.001$) and significantly higher odds of relapse within 1-year (odds ratio, 4.98). Notably, the family environment scores had the greatest impact on GD symptomatology among the clinical covariates and better family conditions were negatively associated with GD symptoms over time. Participants who received psychiatric intervention during the past year had a significantly decreased severity of GD symptoms, leading the authors to state that the assessment and treatment of ADHD and interventions in a family context in children and adolescents with GD may be key factors for improving GD prognosis [18]. The impact of pharmacological ADHD treatments on GD has been investigated by Chang and colleagues [21], who reported that the effectiveness of the treatment of GD in the presence of comorbid ADHD would be satisfactory if underlying symptoms of inattention, hyperactivity/impulsivity, and oppositional defiant disorder were under control by ADHD pharmacotherapy [21]. Indeed, in youth with internet addiction and ADHD, also presenting symptoms of DMDD, methylphenidate, atomoxetine, and the combination of methylphenidate or atomoxetine with aripiprazole should be used as good drug choices for the treatment of GD [21].

5. Brain Structural and Functional Connectivity in ADHD and GD

A comparative meta-analysis of whole-brain voxel-based morphometry (VBM) studies found disorder-specific grey-matter volume (GMV) abnormalities in the putamen in patients with IGD and in the orbitofrontal cortex in those with ADHD, while both conditions shared a lower GMV in the prefrontal cortex [36]. Functional magnetic resonance-imaging (fMRI) research comparing IGD versus ADHD found that ADHD was associated with a disorder-specific hypoactivation of the left median cingulate cortex (MCC), middle temporal gyrus (MTG), right caudate nucleus, and left middle frontal gyrus [36]. Alternatively, individuals with IGD were characterized by the activation of the bilateral precuneus/cingulate cortex (CC), right OFC, MTG, left precentral gyrus, bilateral IFG, and right caudate nucleus [36]. Therefore, the structural and functional alterations in both ADHD and IGD subjects were in the PFC areas, and, more specifically, in those associated with reward, such as the anterior cingulate cortex (ACC).

Another study that investigated whether ADHD and IGD share a similar degree of brain functional connectivity (FC) between the frontal and subcortices [28] found that, at baseline, both subjects with ADHD and those with IGD were characterized by reduced FC from the right-middle frontal gyrus to the caudate and from the left cingulate to the caudate, compared to matched healthy controls (HC). After the baseline assessment, the patients received treatment including CBT and medication for ADHD (methylphenidate or atomoxetine) and IGD (i.e., bupropion or escitalopram), and after one year of treatment the authors found enhanced cortical brain activity within the right-middle frontal gyrus as well as the FC between the cortex and subcortex in those with a good prognosis compared to those with a poor prognosis (i.e., those adolescents who after 1 year of treatment did not reduce their CGI-I ADHD scores of 1 or 2).

A quantitative electroencephalography (qEEG) study performed by Park and colleagues [17] found lower relative delta band power and greater relative beta band power values in temporal areas in an ADHD+IGD group in comparison with patients with only ADHD, while the relative theta power in frontal areas was significantly higher in the subjects with only ADHD in comparison with the healthy controls (HC). The ADHD+IGD group showed no theta band inter-hemispheric coherence diversity in the frontal and central regions and relative beta power compared to the HC group. Such findings led the authors to hypothesize that a higher susceptibility to attention problems may be associated with internet game play as a means to enhance attentional capacity, which is in turn reflected by the beta power in the ADHD+IGD group, which was similar to that found in HC. Moreover, the continual visuospatial working memory and executive function activation during internet gaming may determine an increase in neuronal connectivity among the fronto-central, parieto-occipital, and temporal areas, which is reflected by an increase in inter-hemispheric coherence in those regions. In addition, Han and colleagues (2017) [20] found a hyper-connectivity between those regions related to visual–auditory multi-tasking, motion detection, and the efficient processing of dynamical audiovisual stimuli, leading the authors to hypothesize a training consequence of extended game play.

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