Editor's Choice

Internet gaming disorder in children and adolescents: a systematic review

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ABBREVIATIONS

IGD	Internet gaming disorder
MMORPG	Massively multiplayer online role-playing game

AIM Internet gaming disorder (IGD) is a serious disorder leading to and maintaining pertinent personal and social impairment. IGD has to be considered in view of heterogeneous and incomplete concepts. We therefore reviewed the scientific literature on IGD to provide an overview focusing on definitions, symptoms, prevalence, and aetiology.
METHOD We systematically reviewed the databases ERIC, PsyARTICLES, PsycINFO, PSYNDEX, and PubMed for the period January 1991 to August 2016, and additionally identified secondary references.
RESULTS The proposed definition in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition provides a good starting point for diagnosing IGD but entails some disadvantages. Developing IGD requires several interacting internal factors such as deficient self, mood and reward regulation, problems of decision-making, and external factors such as deficient family background and social skills. In addition, specific game-related factors may promote IGD. Summarizing aetiological knowledge, we suggest an integrated model of IGD elucidating the interplay of internal and external factors.
INTERPRETATION So far, the concept of IGD and the pathways leading to it are not entirely clear. In particular, long-term follow-up studies are missing. IGD should be understood as an endangering disorder with a complex psychosocial background.

Games are an integrative part of human behaviour and experience. During the past two decades, the availability and use of computer technology has dramatically increased and changed the world of leisure activities. Use of the Internet and computer game playing have become common activities for children and adolescents, in addition to social and traditional mass media. Recent data from the USA suggest that 8- to 10-year-olds are busy 8 hours per day, and adolescents more than 11 hours per day, with the recreational use of various electronic media (mobile phones, television and videos, computer use, music, print media, Web pages, social media, not including telephone conversations and text messages). This covers more time than they spend in school or with friends.[1,2]

For most individuals, computer gaming is an enjoyable and stimulating activity.[3–5] Persons with various intra- and interpersonal risk factors may, however, become attracted to using computer gaming as a strategy to overcome individual problems. Gaming and seeking for game-related pleasure may lead to neglecting 'normal' relationships, school or work-related duties, and even basic physical needs. Computer gaming may thus be conceptualized as a continuum from an enjoyable activity to pathological and even addictive use.[6–8]

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5)[9] conceptualizes 'Internet gaming disorder' (IGD) in the chapter 'Conditions for further study' (p.795), suggesting that this proposal is not yet intended for clinical use but that research on this topic is encouraged. The essential feature of IGD is persistent and recurrent participation in computer gaming for typically 8 to 10 hours or more per day and at least 30 hours per week, typically in Internet-based group games (especially massively multiplayer online role-playing games [MMORPG]).

Since IGD has been defined only in 2013, previous literature uses various terms for describing this clinical entity, such as Internet or computer addiction (see 'Definition'). While IGD is typical for adolescents and young adults, preschool and preadolescent children prefer non-Web-based games. Therefore, the American Psychiatric Association definition may not exactly fit for younger children and those playing offline.

Although IGD may be a serious disorder leading to significant impairment of personal and social functioning, the definition, symptoms, prevalence, and aetiology have to be seen in view of heterogeneous, incomplete, and changing concepts, and only a few available clinical studies of scientific quality. We therefore decided to review the scientific

literature on IGD of the past two and a half decades to provide an up-to-date overview on this disorder.

METHOD

This systematic review was conducted according to the structured Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for systematic reviews and meta-analyses.[10] We searched the literature databases ERIC, PsycARTICLES, PsycINFO, PSYNDEX, and PubMed for articles published in English between January 1991 and August 2016. We searched the databases using the following terms: pathological gaming [computer games OR video games OR online games OR Internet games] AND [abuse OR addiction OR compulsive OR dependence OR dependency OR disorder OR effects OR excessive OR habits OR misuse OR pathological OR problem OR problematic].

Applying the PRISMA guidelines for reviewing articles on IGD was beset by various problems: IGD is an expansive topic and includes subchapters such as definitions, symptoms, consequences, aetiology, and related and risk factors. IGD terminology is inconsistent (see 'Definition') and was only defined in 2013 in an amendment to the DSM-5.[9] We therefore used the various search terms listed above to retrieve a maximum number of related articles.

The aim of our review was to provide an overview on the concept and background of IGD. We initially retrieved 3682 articles. Checking the titles and abstracts for relatedness of the content, we excluded: (1) duplicates and articles with content not relevant to IGD, for example articles on compulsive gambling or articles on the use of specific technologies such as mobile phones; (2) articles referring only to adults (we only selected articles investigating children and adolescents); (3) articles without reference to IGD. This reduced the number of relevant articles to 148 (4.0%). We additionally included 104 articles, books, and book chapters cited in the original literature or retrieved in specific searches on subtopics. This summed up to a total number of 252 references in total.

RESULTS

Definition

There are several terms and concepts for describing the pathological use of computer technology: IGD, Internet addiction, technology-based addiction, pathological technology use, pathological video gaming, pathological Internet use, computer addiction, screen addiction, addictions to video games and online role-playing games, game overuse, video game addiction, smartphone addiction (http://www.helpguide.org/articles/addiction/smartphone-and-internet-addiction.htm.), cyber-relationship addiction, net compulsions, information overload, excessive, problem, dependent, pathological, and addicted gamers.

The concept of IGD has been questioned[11] because clinical data on symptoms of 'true' addiction are lacking, negative consequences may be overemphasized, and Internet gaming could be related to inefficient strategies of dealing with life problems, poor time management, or other underlying mental health problems. Interestingly, there is no IGD Medical Subject Headings (MeSH) term available.

What this paper adds

- In representative samples of children and adolescents, on average, 2% are affected by Internet gaming disorder (IGD).
- The mean prevalences (overall, clinical samples included) reach 5.5%.
- Definitions are heterogeneous and the relationship with substance-related addictions is inconsistent.
- Many aetiological factors are related to the development and maintenance of IGD.
- This review presents an integrated model of IGD, delineating the interplay of these factors.

There is also a debate about what amount of time spent with gaming indicates addiction because increased screen time relates to IGD.[12,13] Griffiths and Meredith[14] distinguished between excessive and addicted gamers depending on the consequences of gaming because gaming may also have positive effects, enabling (virtual) social inclusion, increasing self-esteem and social acceptance, and structuring daily routine. Some authors related IGD symptoms to other disorders such as obsessive–compulsive disorder, attention-deficit–hyperactivity disorder, or depression.[15–17]

For the first time, DSM-5 has clearly defined symptom criteria for IGD,[9] requiring five or more of the following nine diagnostic criteria during a 12-month period: (1) preoccupation with Internet games becomes the dominant activity in daily life; (2) withdrawal symptoms when removing the Internet (e.g. irritability, anxiety, or sadness, no physical signs of pharmacological withdrawal); (3) need to spend increasing amounts of time with Internet gaming (tolerance); (4) lacking control of Internet gaming; (5) loss of interest in previous hobbies and entertainment; (6) continued excessive use despite knowledge of psychosocial problems; (7) deception of family members, therapists, or others about the amount of Internet gaming; (8) escape from or relief of negative mood (e.g. feeling helpless, guilty, anxious); (9) loss of important aspects of life (e.g. significant relationships, jobs, or educational/career opportunities).

The nosological classification of IGD[9] is inconsistent (the first of the nine proposed criteria includes 'Internet games' only, but does not definitely exclude 'non-Internet based computerized games' under the heading 'Subtypes', one page later) and still a matter of debate (e.g. Brunborg et al.,[18] Müller et al.,[19] Wölfling et al.)[20] DSM-5 excluded various differential diagnoses, excessive use of social media, online consumption of sexual content, and excessive online gambling, because these were considered to relate to different pathologies. The forthcoming 11th Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-11) will include online or offline 'gaming disorder' (6C51)[21] as a distinct nosological entity after neglecting this disorder in previous editions.[22]

In addition, the DSM-5 definition of IGD excluded offline and video gaming, probably because there is no sufficient evidence for this type of gaming disorder as a separate entity. It is not clear whether this restriction is justified because online and offline gaming share most features, with the exception of direct social reinforcement (team aspects) of online gaming. Furthermore, offline gaming is more predominant in younger children,[23] possibly because Internet access may more easily be restricted in this age group. With one exception,[24] there are no data available on IGD in preschool children.

The criteria for defining non-problematic, problematic, and addictive use of computer games are diverse and probably best characterized as a continuum that considers various dimensions such as severity of impairment, personality, cognitive distortions, psychopathology, and social functioning.[25,26]

Considering problematic computer, online, or video gaming as a behavioural addiction has led to significant controversy. For classifying IGD, the recommendation is to differentiate between high engagement, addiction, gaming enthusiasm, and problems related to excessive gaming. High engagement with gaming, contrary to game addiction, does not lead to negative consequences.[18,27–32]

Pathological computer gaming and behavioural and substance-related addictions share similarities.[33,34] Pathological gamers share neurobiological correlates with behavioural and substance-related addictions.[8,35–39] An important aspect in this debate relates to the definition of addiction,[40] which includes characteristic elements such as salience, tolerance, withdrawal, relapse, mood modification, and tolerating negative consequences as key components.[40,41]

Symptoms

IGD-related symptoms include excessive screen time, preoccupation with gaming, salience, tolerance, loss of control, conflictuousness, mood imbalance, and relapse.[8,42–44]

Conflictuousness means repeatedly having internal conflicts or conflicts with others in relation to the excessive gaming activity.[41] Mood imbalance (e.g. feelings of guilt, depression) occurs as a consequence of losing control of gaming.[45] Salience describes a condition where gaming has become the most important activity in one's life; and relapse refers to the tendency to refer to earlier gaming patterns after periods of abstinence.[46,47]

When gamers are consistently engaged or preoccupied with thoughts about gaming, or crave gaming during abstinence, they are about to lose control.[47] King et al.[46] described symptoms of withdrawal, loss of control, and conflictuousness as the core symptoms of pathological gaming, and considered other symptoms as peripheral (i.e. not essential for the diagnosis of IGD). Charlton and Danforth[41] identified conflictuousness, symptoms of withdrawal, relapse/reinstatement, and behavioural salience as core symptoms; and cognitive salience, tolerance, and euphoria as peripheral symptoms. Addicted gamers, primarily exhibiting core symptoms, spend more time with gaming than those exhibiting only peripheral symptoms.

Problematic use may lead to tolerance, an important symptom of addiction.[8] Gunuc[33] indicated that tolerance and time spent with gaming may play an important role in developing addiction because screen time increases with addiction. Tolerance is not always a symptom of addictive behaviour, just as its absence does not exclude addiction. If a gamer does not increase his gaming time (e.g. because of restricted access), psychological but not behavioural tolerance may predominate.[33] If tolerance develops, symptoms of withdrawal are likely to increase.[33,48]

Craving and withdrawal are important symptoms of pathological gaming.[49,50] Different conceptualizations of withdrawal[9,49] may explain why symptoms of craving and withdrawal were not detected in some studies. Kaptsis et al.[49] speculated that mild withdrawal symptoms may be overlooked because the environment of the gamers has adjusted to the addiction, or because symptoms had only occurred in specific addictive subtypes. According to the DSM-5 classification,[9] withdrawal symptoms include sadness, irritability, and anxiety, whereas King et al.[50] found patients being bored and driven for mental stimulation. A recent article[51] suggested that a better definition of withdrawal symptoms and their duration is required.

Craving is not listed as a symptom of IGD in the DSM-5. It might be considered an aspect of withdrawal.[49] Related cues may activate specific brain regions and induce craving sensations.[36,52] Dong et al.[53] found craving and related changes in functional magnetic resonance imaging (MRI) in patients with IGD but not in subjects with recreational game use (RGU). Cue-induced craving is assumed to play an important role in maintaining addictive behaviour and producing relapse.[54]

Although cue-induced craving was much stronger in Internet addicts, Niu et al.[52] also described craving symptoms in non-addicted Internet users.

Online gaming is a highly heterogeneous condition and depends on a wide range of psychological factors. It is important to understand gamers' individual motives and psychological factors to plan effective interventions. Billieux et al.[55] described five subtypes of online gamer: two non-problematic and three problematic, as follows. (1) Regulated recreational gamers (non-problematic): 'low impulsivity traits, high self-esteem'. (2) Regulated social role-players (non-problematic): 'low levels of self-esteem, low impulsivity, and motivations related to social exchange and role-playing'. (3) Unregulated achievers (problematic): 'high scores on all impulsivity facets and primarily motivated by achievement in the game'. (4) Unregulated escapers (problematic): 'low achievement and high escapism, poor self-esteem'. (5) Hard-core gamers (highly problematic): 'highest adverse consequences resulting from gaming and high involvement in the game'.

Several studies[56–59] investigated the validity of the DSM-5 criteria, showing that some of them were more suited than others: 'escape' and 'preoccupation' were judged as

less suited.[56,57,59] 'Deception' in the study of Ko et al.[57] was less suited for identifying IGD, whereas other studies[59,60] found the opposite. 'Giving up other activities' and 'tolerance',[56,59] as well as 'withdrawal',[59] and 'loss of control',[56] were also debated. In addition, Ko et al.[57] suggested 'craving' as a candidate criterion. Another topic of controversy is the problem of a cut-off level because, so far, there is no criterion standard for defining IGD.[56,57,59]

Consequences

Problematic gaming may lead to several negative psychosocial consequences and mental health problems affecting available time, work, education, family, partnership, friends, social life, psychosocial well-being, social competence, leisure activities, self-esteem, and loneliness.[61–65] Professional and academic problems may include poor grades, academic failure, and financial problems.[62,65] There is a negative relationship between academic performance and pathological gaming, affecting self-esteem and self-confidence.[65] A minority of gamers reported that gaming resulted in an overall negative effect on quality of life.[62] Furthermore, Andreassen et al.[66] emphasized the relationship between psychiatric disorders such as anxiety and depression and gaming addiction. Messias et al.[67] found a higher risk of sadness, suicide ideation, and suicide planning in heavy gamers involved with screen times of more than 5 hours a day. Pathological media use may also reduce sleep duration and disrupt sleep patterns.[62,68] IGD is also associated with various somatic health and medical consequences, such as auditory hallucinations, enuresis, encopresis, wrist, neck, and elbow pain, tendosynovitis ('nintendinitis'), obesity, skin blisters, calluses, sore tendons, hand–arm vibration syndrome, and peripheral neuropathy.[63,69] In addition, psychosocial and medical consequences of IGD are similar in males and females.[64]

To distinguish between causes and consequences, structural equation models have to be established on the basis of longitudinal study data. Only a few studies have applied such models, which mainly suffer from sample sizes that are too small.[70]

Prevalence

Prevalence rates of IGD vary widely between studies from different countries, ranging from an estimated 0.6% in a Norwegian survey[71] up to an extreme of 50% in Korea.[72] This may be caused by differences in assessing instruments, study population,[8] and diagnostic criteria of IGD. Prevalence rates are highest in Eastern Asian countries and male adolescents aged 12 years to 20 years.[9] The median prevalence rate for computer and IGD as calculated from Table I was 5.5%. Selecting the 10 population-based studies listed in Table I, we obtained a median prevalence of 2.0%, which is close to the number of 1.6% of a recent European population-based study.[19]

A recent review on 13 longitudinal epidemiological studies[73] showed a moderate to high symptom stability over 2 years, and protective social factors.

Sex differences

IGD may be observed up to five times more often in male children: IGD was diagnosed in 11.9% of the males and in 2.9% of the females in a large US study.[74] Only two studies[75,76] reported no sex-related difference in addicted gamers.

Age

The influence of age on IGD prevalence is not clear. Unfortunately there are no studies available for younger children, with one exception.[24] The highest prevalence of IGD was found in adolescents;[77] only one recent study identified more addicted adults than adolescents.[30]

Aetiology

The aetiology of IGD is complex and not fully understood. IGD 'can last for years and is not solely a symptom of comorbid disorders'.[13] There are internal and external factors related to developing and maintaining the disorder. In addition, genetic, learning, motivational, game-related, and neurobiological aspects must be considered. It is unclear whether psychiatric symptoms predispose for, or follow, IGD because longitudinal studies are scarce.[78]

Internal factors

Among the internal factors, deficient self-regulatory and decision-making abilities as a consequence of dysexecutive problems, mood and reward system dysregulation, and avoidant behaviour (escapism, deficient coping with negative emotions), low self-esteem, poor self-efficacy, and neurobiological factors may be involved.

Dysexecutive problems, deficient self-regulation, and decision-making. Deficient inhibitory control, sensory–motor coordination, and executive control including self-control have been described in patients with IGD.[37,79,80] Lower functional connectivity of executive control networks along with impaired executive functions were described in individuals with IGD.[80] Compared with healthy individuals, the anterior insula and the dorsolateral prefrontal cortex are less activated during decision-making tasks in patients with IGD.[81,82] In addition, the volume of the striatum is increased in patients with IGD, which relates to impaired cognitive control.[83,84] Decreased inhibition of impulsivity entails the disability to control compulsive gaming despite serious negative consequences.[85] Impaired functioning of the amygdala, responsible for emotional control, may be associated with increased emphasis of emotions and immediate rewards, leading to excessive gaming without paying attention to negative long-term consequences.[85]

Dysregulation of mood and reward system, avoidant behaviour. Negative and depressed mood, stress, anxiety, and preference for immediate rewards[86,87] are associated with pathological gaming.[63,88] Kwon[89] hypothesized that IGD, such as drug abuse, may serve as a self-destructive strategy for escaping unpleasant real-life problems. Li et al.[90] suggested depression to mediate the relationship

Table I: Prevalence of computer and Internet gaming disorder (IGD) across various countries

Country	Study	Investigation	Age group	Sex (M:F)	Method(s)	Prevalence (%)	Representative
Australia	Thomas and Martin[208]	CGA	12–54y	42:58	YIAT	5.0	Y, students
Australia	Thomas and Martin[208]	IA	12–54y	42:58	YDQ, DSM-IV-TR	4.6	Y, students
Austria	Batthyány et al.[120]	CGA	13–18y	54:46	CSVK-R	2.7	Y, students
China	Cao et al.[231]	IA	12–18y	50:50	YDQ	2.4	Y, students
China	Xu and Yuan[232]	Game addiction	13–18y		DSM-IV	21.5	Y, students
China	Cao et al.[233]	PIU	10–24y	51:49	YIAT	8.1	Y, students
Germany	Grüsser et al.[234]	Excessive computer and VG playing	11–14y	54:46	CSVK, ICD-10, DSM-IV-TR	9.3	Y, students
Germany	Gruesser et al.[6]	CGA	Average 21y 1mo	94:6	ICD-10	11.9	Y, students
Germany	Rehbein et al.[29]	VGD	Average 15y 4mo	51:49	VGDS	2.8	Y, students
Germany	Rehbein et al.[29]	VGD	Average 15y 4mo	51:49	KFN-CSAS	1.7	Y, students
Germany	Wölfling et al.[235]	CGA	13–18y		ICD-10	7.5–8.4	Y, students
Germany	Müller et al.[236]	PIU	8–17y	?	AICA-S	11.3	N, patients
Germany	Müller et al.[165]	IA	14–94y	48:52	AICA-S, CSV-S	2.1	Y
Germany	Dreier et al.[75]	IGD	12–18y		AICA-S	5.2	Y, students
Germany	Paulus et al.[24]	CGA	4y 5mo–8y 2mo	50:50	YC-CGD	1.9	Y, children
Europe	Müller et al.[19]	IGD	14–17	47:53	AICA-S	1.6	Y
International	Porter et al.[114]	Problem VG use	14–>40y	93:07	VGUQ	8.0	N, students
International	Hussain et al.[141]	Online game addiction	12–62y	77:23	DSM	3.6–44.5	N, gamers
Iran	Zamani et al.[237]	CGA	Grade 2 students	53:47	QACG	17.1	Y, students
the Netherlands	van Rooij et al.[34]	Online VG addiction	13–16y	49:51	CIUS	1.5	Y, students
the Netherlands	Haagsma et al.[196]	PGB	14–81y	50:50	GAS	1.3	Y
the Netherlands	Lemmens et al.[238]	IGD	13–40y	50:50	IGD scales (DSM-5)	5.5	Y
Norway	Bakken et al.[239]	IA	16–74y	47:53	YDQ	1.0	Y
Norway	Arnesen[240]	VGA	16–40y	44:56	DSM-IV-TR	0.6–4.0	Y
Norway	Mentzoni et al.[71]	Problematic VG use	15–40y		GASA	0.6	Y
Norway	Wittek et al.[241]	VGD	16–74y	63:37	GASA	1.4	Y, gamers
Singapore	Choo et al.[242]	Pathological VG	9–13y	73:27	DSM-IV	8.7	Y, students
Singapore	Gentile et al.[13]	Pathological VG use	12–18y	73:27	DSM-IV-TR	9.0	Y, students
South Korea	Hur[72]	IAD			IAII and IAD	50.0	Y, students
South Korea	Kim et al.[243]	IA	15–16y	35:65	YDQ	1.6	Y, students
South Korea	Lee and Han[244]	Online game addiction	Grade 5 and 6 students		Own, based on YIAT	2.5	Y, students
South Korea	Park et al.[245]	IA		70:30	IAS	10.7	Y, students
South Korea	Jeong and Kim[246]	IA	15–16y	53:47	IAT	2.2	Y, students
Spain	Tejeiro Salguero and Morán[247]	Problem VG playing	13–18y	54:46	PVP	9.9	Y, students
Spain	Lopez-Fernandez et al.[248]	IGD	11–18y	53:47	PVP	7.7	Y
Taiwan	Ko et al.[249]	IA	Average 13y 7mo	52:48	CIAS	7.5	Y, students
Taiwan	Wan and Chiou[250]	Online game addiction	17–24y		OAST	34	N
UK	Fisher[251]	VGA	11–16y	48:52	DSM-IV	19.9	Y, students
UK	Griffiths and Hunt[252]	Dependence on computer games	12–16y	58:42	DSM-III-R	19.9	N
UK	Lopez-Fernandez et al.[248]	IGD	11–18y	67:33	PVP	14.6	Y
USA	Gentile[74]	Pathological VG use	8–18y	50:50	DSM-IV	8.5	Y

M, male; F, female; CGA, computer game addiction; YIAT, Young's Internet Addiction Test; Y, yes; IA, Internet addiction; YDQ, Youth Dependency Questionnaire; DSM-IV-TR, Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision; CSVK-R, Fragebogen zum Computerspielverhalten bei Kindern [Questionnaire for computer gaming behaviour in children]; PIU, problematic Internet use; VG, video game; ICD-10, International Statistical Classification of Diseases and Related Health Problems, 10th Revision; VGD, video game dependency; VGDS, Videogame Dependency Scale; KFN-CSAS, Lower Saxony Research Institute of Criminology: Computer Game Addiction Scale; AICA-S, Assessment for Internet and Computer Game Addiction; N, no; IA, Internet addiction; CSV-S, Scale for the Assessment of Pathological Computer-Gaming; YC-CGD, Young Children – Computer Gaming Disorder Questionnaire; VGUQ, Video Game Use Questionnaire; DSM, Diagnostic and Statistical Manual of Mental Disorders; QACG, Questionnaire of Addiction to Computer Games; CIUS, Compulsive Internet Use Scale; PGB, problematic gaming behaviour; GAS, Gaming Addiction Scale; VGA, video game addiction; GASA, Game Addiction Scale for Adolescents; IAD, Internet addiction disorder; IAII, Internet Addiction Impairment Index; IAS, Internet Addiction Scale; IAT, Internet Addictions Test; PVP, Problem Video Game Playing scale; CIAS, Chen Internet Addiction Scale; OAST, Online gaming Addiction Scale for Adolescents in Taiwan; DSM-III-R, Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised.

between actual–ideal self-discrepancy and escapism. On the other hand, escapism and game immersion are mediating factors between depression and problematic gaming, promoting IGD (https://bpistone.wordpress.com/2012/09/03/).

Self-esteem and self-efficacy. Low self-esteem was also found to trigger pathological gaming behaviour.[91] Excessive gamers are attracted to games because gaming stimulates the experience of power and autonomy, and strengthens self-esteem. Furthermore, pathological gamers tend to overvalue gaming rewards, activities, identities (avatars), or items. This stimulates preoccupation with gaming and loss of interest in less attractive real-life activities. Avatars (simulated identities in a game) may enhance the feelings of empowerment and strength, and facilitate escape from real-life problems.[91]

Neurobiology. Recent research describes neurobiological anomalies in pathological gamers such as altered grey matter volume, functional connectivity, and activation in specific brain regions (especially the ventromedial prefrontal cortex) and neurobiological correlates to disorder-specific behaviours and symptoms.[92] It is not clear whether these alterations are causes and risk factors for IGD or consequences resulting from excessive gaming. The most commonly used methods (electroencephalography, positron emission tomography, functional MRI, structural MRI [voxel-based morphometry, diffusion-tensor imaging]) were mainly applied in adults.

Although pathological gaming is considered a behavioural addiction (e.g. Leeman and Potenza,[38] Griffiths et al.,[63] Ong et al.,[93] Vousooghi et al.),[94] multiple similarities have been described between addictive gaming and other addictions such as substance dependency or pathological gambling. For example, Fauth-Bühler and Mann[95] found loss of sensitivity, increased reactivity to related cues, increased impulsivity, and altered reward-based learning in addictive gamers and pathological gamblers compared with healthy individuals.

Impulsive behaviours are associated with deficits of frontostriatal networks, interhemispheric connectivity, and an altered structure of the insula.[96,97] Dysfunction of the prefrontal cortex and disrupted frontostriatal connectivity indicate that the frontal lobe fails to regulate emotion-driven urges.[96,98] Gaming-related stimuli induce increased urges and provoke enhanced activation of frontolimbic and mesocorticolimbic reward systems in pathological gamers.[95,99] The same brain areas are also involved in cue-induced craving with other addictions.[36,38,99,100] Moreover, the temporal homogeneity of the regional blood-oxygen-level dependent signal in functional MRI, which presumably indicates neural activity,[101] was found to be increased in the posterior cingulate cortex in patients with IGD and with alcohol use disorder.[102]

Substance-related and behavioural addictions affect the 'reward circuit'.[38,79,103] The mesolimbic dopamine pathway is particularly important and includes dopaminergic neurons from the ventral tegmental area to the nucleus accumbens. Dopamine levels that are too low or too high are associated with impulsivity and risky decisions.[104] Excessive Internet and game use is associated with an overall reward deficiency that is related to reduced dopaminergic activity, similar to that in drug abuse.[8,79] Videogame playing was found to induce dopamine releases similar to cocaine.[79] Some authors have suggested an association between IGD and a dysfunction of the dopaminergic system.[79] Vousooghi et al.[94] found a reduced number of D5 dopamine receptors in computer game addicts compared with healthy individuals.

Hoeft et al.[105] found sex differences when investigating activation and connectivity of brain regions associated with the mesocorticolimbic reward system.[8] The higher risk of gaming addiction for males could be related to these neuronal differences.[65]

In summary, neurobiological and functional studies provide strong evidence for structural and functional brain changes in pathological gamers.

Personal risk factors. Personal risk factors include low self-esteem,[55,106–111] social isolation,[108,109,111,112] decreased interpersonal relationships and few or no friends in real life,[113,114] impaired social functioning,[13] limited other leisure or recreational activities,[19,59] low educational or academic achievement,[18,19,115–118] and increased truancy, low commitment to school, and poor school or academic performance or unemployment.[19,27,29,74,119–122]

Frölich et al.[122] found no specific psychiatric disorders associated with computer game misuse or addiction. The authors speculated that their results supported the idea of IGD as a distinct psychiatric entity. Hart et al.,[123] in contrast to Kim et al.,[124] Rehbein et al.,[29] and Subramaniam et al.,[125] found no self-reported physical reactions or increased stress levels in adolescent students with IGD.

Social factors such as poverty, social exclusion, poor parental competence and supervision, and inconsistent parental behaviour play a role in developing IGD. Socio-cultural influences such as gender roles, family structure, cultural values, and personal beliefs should also be considered as related to IGD.[126] Only one study reported multiple comorbid conditions of IGD in younger children.[127]

Individual factors such as sex, age, personality traits, and various psychological factors may be related to an increased risk of developing and maintaining IGD.[43,55,128]

Sex. Males, independent of age, bear a higher risk[8,19,43,74,107,129–131] of developing IGD, participating in MMORPGs,[132] and playing more violent games (e.g. Lemmens et al.)[133] They play more often for excitement and for making friends[107] than females. Females engage in gaming for passing time, social networking, texting, online shopping, but not for fighting or re-enacting negative emotions.[30,43,66,107,134–138] Wei et al.[112] reported that female gamers presented with shorter durations of online gaming and shorter screen times. Social phobia also increases the risk of IGD,[112] independent of sex.

Age. Age shows an inversely U-shaped relationship to IGD[8,43,66,125,137,139] and correlates with the time spent

computer gaming.[140,141] Older adolescents have the highest probability of becoming game addicted.[142] This may be related to a greater technology affinity of 'digital natives'[66] and to the developmental tasks of this age period (personal goals vs life optimization).[143] Adolescents are especially vulnerable to the negative effects of IGD.[133]

Personality traits. Personality traits are related to developing IGD,[144,145] especially impulsivity,[55,110,146–148] lower self-control/self-regulation ability,[124,146,149–151] sensation-, stimulation-, and/or novelty-seeking,[119,152,153] inclination to boredom,[119] risky behaviour,[154] hostility/animosity,[119,155,156] and enhanced levels of aggression.[19,83,110,124,146,153,154,157,158]

Gruesser et al.[6] found only a weak association between IGD and aggressive behaviour. Because of the cross-sectional design of most studies, a causal link between aggressive behaviour and IGD at present cannot be proved.[133]

The contribution of the 'Big Five' personality traits (neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness)[159] to developing and maintaining IGD is not clear. Introversion, shyness, or low extraversion have been associated with IGD.[116,160–168] Data about trait empathy are inconsistent, ranging from decreased empathy (e.g. Bartholow et al.)[169] to no differences except for soft skills deficits.[150,170] Other personality traits related to IGD are decreased conscientiousness,[128,160,164,165,167,168] decreased openness,[167] agreeableness, resourcefulness,[128,150,161,171,172] irritability,[110,146] and high neuroticism/low emotional stability.[128,153,161,163,165,168,171–175] State and trait anxiety[153,163] are characteristic of IGD. Narcissistic,[124,176] avoidant, and schizoid interpersonal traits are also important for IGD.[177]

It must be stated that personality traits may change during individual development.[178] Unfortunately, most studies investigating the relationship between personality traits and IGD did not control for this age dependency. Future studies should therefore consider such effects.

The preference of problematic game users for online relationships is related to loneliness, deficient soft skills,[30,64] and social inhibition.[114] Being single bears a higher risk for developing IGD.[43] Caplan[179] described that the relationship between loneliness and IGD could be mistaken as social anxiety.

Substance use disorder. Ong et al.[93] found various personality factors associated with adolescent substance use disorder and IGD. Substance use disorder was associated with a higher risk of childhood adversity and delinquency,[132] and IGD more with traumatic childhood experiences.[180]

Personal motives and preferences. Personal motives and preferences such as escapism,[8,56,181,182] immersion, achievement, and affiliation are related to IGD.[55] Wan and Chiou[183] described IGD effects as more related to relief from dissatisfaction than to gaining satisfaction. Game overuse may be related to three motivational factors: emotional regulation against dysphoria, escaping from real-life problems, and developing personal relationships with other gamers.[184] The Motives for Online Gaming Questionnaire cites seven main online gaming motives: escape, coping, fantasy, skill development, recreation, competition, and social.[185]

Cognitive performance. The relationship between cognitive performance and IGD is not clear. Hyun et al.[131] found no differences in cognitive performance between addicted and non-addicted gamers. Because of the cross-sectional design of most clinical studies, the direction of causality is not clear. Park et al.[186] found lower comprehension scores resulting in lower social intelligence, and a negative relationship between gaming activity and performance in attention tasks. The earlier IGD manifests and the longer it lasts, the lower the performance in attention tasks.

External factors

Several external factors promote and maintain IGD against better insight.[187] Possible explanations between external factors and IGD are provided by learning theory (classical and operant conditioning, and gratifications theory)[188] and social–cognitive theory (model learning).[189,190] External factors include familial, social, and game-related factors.

Familial factors. Poor relationships with parents and peers are associated with IGD.[45] Poor parental control and negative role models, as well as a positive parental attitude towards adolescent substance use, predict both substance use and IGD.[191,192] Particularly ignorant, oppressive, and hostile parents, single parent families, and a broken home context increase the screen time of adolescents.[193] In the Berlin Longitudinal Media Study, a controlled group study involving 1207 schoolchildren over a period of 4 years, 'family violence' and 'poor parental care' were identified as key risk factors of IGD.[194]

Social factors. Team aspects are important motivational factors for IGD; like-minded players may interact in real life and in virtual environments. Communication and social interaction are essential ingredients of many games, especially MMORPGs. Haagsma et al.[195] reported that online social interaction strengthens meaningful feelings and self-regulation, and reduces negative feelings such as loneliness and boredom. Shy and isolated children find a safe and rewarding way of interacting with peers in the virtual world. The avatar skin may provide a desirable appearance. In particular, MMORPGs create and provide a social environment that is built solely on gaming skills and availability on screen.

The virtual social environment enables the gamer to interact with people having similar (gaming) interests. This rather reinforces gaming instead of criticizing it.[91] Virtual relationships thus become increasingly more important for the gamer, and virtual rank and status increasingly satisfy otherwise deficient social needs and reinforce online presence.[91,196] Moreover, the guild or clan may exert social pressure to attach gamers to the game and keep them active.[45] Gamers will receive social rewards for gaming skills in the real peer group as well. Pathological gamers tend to overestimate gaming rewards, activities, virtual identities, or hard-earned 'valuable' items (weapons, life

energy, treasures, etc.). Overestimating such features may be another reason for losing interest in real-life activities.[91]

Wan and Chiou[183] found no relationship between experiencing a 'flow state' and excessive gaming, whereas Hull et al.[197] highlighted the experience of a flow state as 'heightened levels of a sense of time being altered during play', and that pursuing this 'high' was a risk factor for IGD.

Game-related factors. Structural characteristics of specific game genres will promote a pathological gaming behaviour:[198] game 'immersion' and increased weekly and holiday screen time;[13,118,164,199–201] strong gaming urges;[201,202] non-age-appropriate shooter games or games with forbidden content (forbidden fruit hypothesis);[19,203,204] (over-) involvement in social networks;[199] and becoming familiar with specific game characteristics (mental constructs developed during regular participation).[205,206]

Internet and role-playing games possess more addictive potential than offline games because of their inherent social reinforcements.[195,207,208] In particular, MMORPGs include addiction-promoting features that attach gamers to the game;[45,209] for example, a never-ending design, the possibility of acquiring power, glory, and attractive items such as invincible armament, their hierarchical social organization (e.g. in guilds), and a regular membership fee,[210] rewards and punishments (earning scores, reaching levels), narrative elements (e.g. an interactive story), realistic graphical quality, and fast loading times.[209] Another method to increase game involvement is monetarization: the obligation to purchase items in 'free-to-play' (initially cost-free) games.[75] Kuss et al.[198] found specific motivation, especially 'escapism', and 'mechanics', a subcomponent of achievement, but not total screen time to predict MMORPG addiction. MMORPG addiction in college students was predicted by five critical factors: curiosity, role playing, belonging, obligation, and reward.[211]

Gaming equipment and permanent Internet access influenced adolescents' IGD rates: possessing a PlayStation but not their own personal computer, Game Boy, television, or a powerful Internet access in their own room promoted game addiction.[74,122,199]

Additional aspects. Beranuy et al.[45] identified three factors involved in motivating gamers: entertainment, escapism, and virtual friendships. With increasing screen time, MMORPG gamers start to lose control and narrow their behavioural focus. Griffiths and Beranuy,[212] investigating subjective deficiencies in MMOPRG gamers, found lack of real friends, difficulties in relationships, and problems with physical appearance as key motivational factors for gaming.

Furthermore, the use of non-age-appropriate games or games with forbidden content ('forbidden fruit hypothesis'),[19,203,204] involvement in social networks,[199] and Internet access at home[213] as well as psychopathological comorbidities such as attention-deficit–hyperactivity disorder, depression, social anxiety, autism, etc. and other additional risk factors will promote IGD.

Complex models

Considering the complex aetiology of IGD, various models of the disorder have been developed. These models include behavioural, psychopathological, and social aspects with various weights. Cognitive–behavioural dimensions[144,214] include maladaptive cognitions and thoughts going along with negative self-value, self-doubts, and poor self-efficacy. These deficits will promote and maintain pathological Internet use. Defence mechanisms used by pathological gamers are 'stonewalling', minimizing, blaming (e.g. stress), excusing, rationalizing, and attacking.[214] Strong emotions such as feelings of excitement when winning or finishing a game, powerfulness, relief (escaping from real-world problems), and friendships with 'electronic friends' will promote excessive gaming behaviour. Some models were empirically evaluated.[196]

Haagsma et al.[195] proposed and evaluated a cognitive behavioural model of IGD. The key features of this model relate to preferences of social interaction, deficits in mood and self-regulation, ruminations, and compulsive aspects. The first three factors explained 79% of the variance in their model. In another publication,[215] the authors examined the model of planned behaviour theory, and found clients' perceived lack of control over gaming as the main factor for predicting IGD.

Dong and Potenza[103] proposed a cognitive–behavioural model of IGD. Because of an increased reward sensitivity and decreased lack of considering losses,[8,216,217] as well as deficient response inhibition[218,219] and executive control,[80] the authors speculated that deficient cognitive control in association with enhanced reward seeking would lead to increased gaming. Gamers exhibit deficiencies in impulse control, attentional capabilities,[220–222] overall cognitive functioning,[8,223] and impaired risk perception,[224] favouring risky decisions because they strive for immediate positive rewards and neglect negative long-term consequences for social or work domains in real life.[225]

The multi-disciplinary aetio-pathogenetic model of Dreier et al.[226] and Müller et al.[227] includes psychological (e.g. dysfunctional beliefs), social (e.g. familial dysfunctions, social insecurity), and neurobiological (e.g. neurotransmitter dysregulations, dysfunctions of the reward system) IGD-promoting factors. Game-related (e.g. success, competition, exploration), environmental (e.g. availability, accessibility, popularity), and personal characteristics (e.g. impulsivity, negative self-concept, neuroticism), motivational states (e.g. escapism, compensation, coping), and specific game features (e.g. reward, curiosity, obligation) help to maintain IGD within vicious circles despite negative consequences.

Another complex bio-psycho-social process model, the Interaction of Person-Affect-Cognition-Execution (I-PACE) model,[228] integrates psychological and neurobiological aspects of IGD. In short, a person defined by their core characteristics (influenced by numerous biological, motivational, and social protective and risk-increasing factors) decides to use a certain application in response to

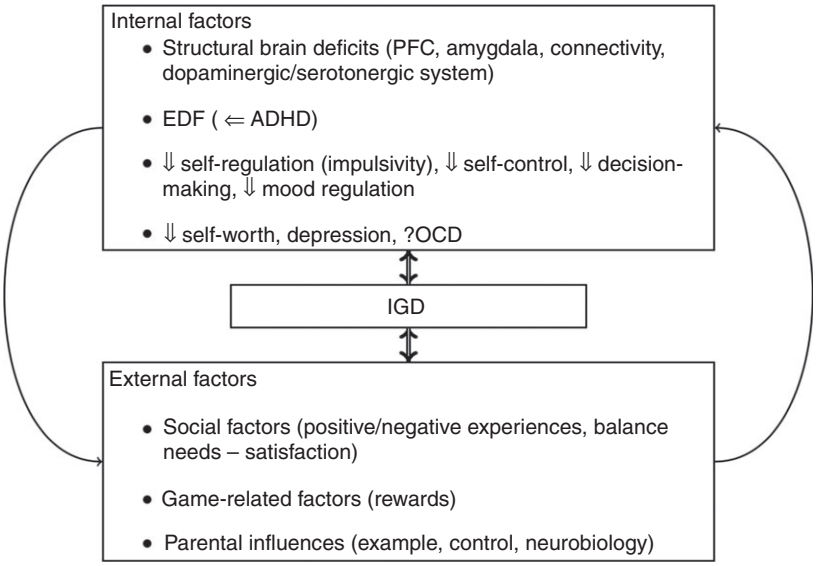

Figure 1: An integrated model of Internet gaming disorder (IGD). PFC, prefrontal cortex; EDF, executive dysfunction; ADHD, attention-deficit–hyperactivity disorder; OCD, obsessive–compulsive disorder.

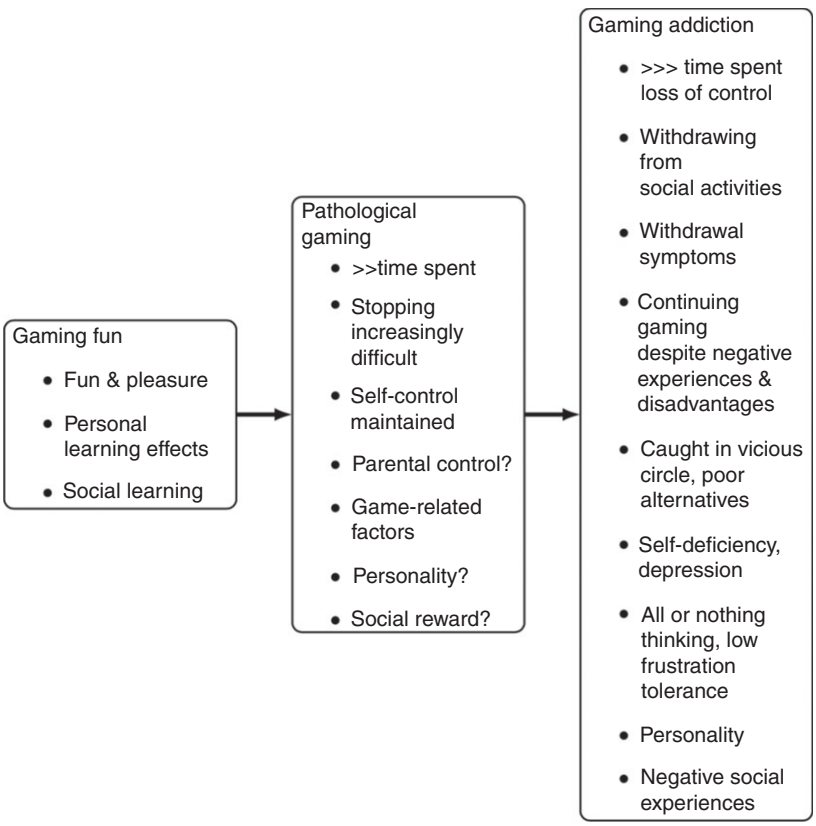

Figure 2: The pathway of gaming fun, pathological gaming, and gaming addiction.

their actual situation and their affective and cognitive responses. Internet gaming disorder (IGD) then develops as a result of the described personal characteristics and affective responses under aspects of gratification and the specific neurobiological conditions of diminished executive control, despite negative consequences in daily life.

DISCUSSION

Many IGD-affected adolescents will endanger their health, fail academically, and may become isolated and depressive. Reviewing the scientific literature, the evidence of a diagnostic entity of IGD and the pathways to the disorder are not entirely clear. In particular, long-term follow-up studies are still lacking. There is some evidence that IGD does not affect anyone but that multiple, often interacting personal, familial, and environmental risk factors and comorbid conditions will contribute towards developing and maintaining the disorder.

Because the paucity of available high-quality, long-term studies impeded us in analysing available studies according to the PRISMA guidelines,[10] we can only provide a systematic review on IGD, summarizing the available evidence.

The DSM-5 tentative definition of IGD[9] is a good starting point for collecting diagnostic evidence, tolerance, loss of control, giving up other interests, and excessive use despite clear-cut psychosocial and health-related problems, representing the most stringent criteria. There are, however, weaknesses of the DSM-5 definition; it excludes other differential diagnoses, and alternative media and content, and has the problem of defining 'hazardous' screen times.[18–20]

Developing IGD requires several complex interacting internal and external factors.[103,196] Among these, problems of self-regulation and decision-making, dysregulation of mood, and reward systems are based on neurobiological deficits that may also explain sex differences.[65] Among the external factors, familial deficits, including intrafamilial violence and poor parental care, and deficient social skills may increase the risk of developing IGD, especially of becoming addicted to MMORPGs[195] or action real-time strategy (shooter) games such as Multiplayer Online Battle Arena.[229] Finally, several game-related personally and socially reinforcing factors, as well as steadily improving technical performance, will promote IGD.[207,208,211]

The wide range in IGD prevalence rates relates to different definitions of IGD, regional differences, and different methods of assessment. We found a median IGD prevalence of 5.5% (Table I) and a median of 2.0% for population-based studies that seems more accurate. Male adolescents usually manifest higher prevalences than females.[206] Most studies cited in our review investigated adolescents. Only a few individual studies[1,13,74,87,118] and one review article[230] included data on children. To the best of our knowledge, there is only one study available investigating IGD in preschool children.[24]

Predisposing comorbidities and health-related consequences are commonly observed in IGD.[20,29,71,184] Causal associations cannot be analysed because IGD and comorbid disorders such as attention-deficit–hyperactivity disorder, depression, or social anxiety share common aetiologies, and may interact. Longitudinal studies that could resolve this question are lacking. Low parental competence, personality traits, and problems of self-esteem or social skills may contribute to developing and maintaining IGD.

Summarizing aetiological knowledge, we suggest an integrated model of IGD (Fig. 1) that delineates the interplay of external and internal factors. External and internal factors are interrelated with each other and with IGD. IGD may aggravate existing deficits and vice versa; poor social relations will motivate for gaming, and spending increasing time with gaming will aggravate poor relationships, thus further reinforcing IGD.

Gaming reinforces itself by multiple mechanisms, as explained in the section on 'External factors'. The pathway towards addiction is characterized by a change of emphasis from fun, through losing control, to obsession. Figure 2 summarizes this development.

In conclusion, we have reviewed the current literature for characterizing IGD as a complex, endangering disorder with an intricate psychosocial background, and many personal, neurobiological, familial, social, and game-inherent IGD-promoting factors.

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RESUMEN

TRASTORNO DEL JUEGO EN INTERNET EN NIÑOS Y ADOLESCENTES: UNA REVISIÓN SISTEMÁTICA

OBJETIVO El trastorno del juego por Internet (IGD, siglas en inglés) es un trastorno grave que provoca y mantiene un deterioro personal y social relevante. El IGD ha sido considerado en vista de conceptos heterogéneos e incompletos. Por lo tanto, nosotros revisamos la literatura científica sobre el IGD para proporcionar una visión general enfocada en sus definiciones, síntomas, prevalencia y etiología.
MÉTODO Se revisaron sistemáticamente las bases de datos ERIC, PsyARTICLES, PsycINFO, PSYNDEX y PubMed en el período desde enero del 1991 a agosto del 2016, y adicionalmente se identificaron referencias secundarias.
RESULTADOS La definición propuesta en el Manual Diagnóstico y Estadístico de los Trastornos Mentales, Quinta Edición proporciona un buen punto de partida para diagnosticar el IGD, pero conlleva algunas desventajas. El desarrollo del IGD requiere de varios factores internos que interactúan, tales como deficiencias en el *yo* la regulación del estado de ánimo y las recompensas, problemas en la toma de decisiones y factores externos, tales como antecedentes de familias deficientes y las habilidades sociales. Además, factores específicos relacionados con el juego pueden promover el IGD. Resumiendo, el conocimiento etiológico, sugerimos un modelo integrado del IGD dilucidando la interacción de factores internos y externos.
INTERPRETACIÓN Hasta ahora, el concepto del IGD y las vías que conducen a él no son del todo claras. En particular, faltan estudios de seguimiento a largo plazo. El IGD debe entenderse como un peligro de trastorno con un fondo psicosocial complejo.

RESUMO

DESORDEM DO JOGO DE INTERNET EM CRIANÇAS E ADOLESCENTES: UMA REVISÃO SISTEMÁTICA

OBJETIVO A desordem do jogo de internet (DJI) é uma desordem séria causando e mantendo dificuldades pessoais e sociais. A DJI tem sido considerada em vista de conceitos heterogêneos e incompletos. Portanto, revisamos a literature científica sobre DJI para fornecer uma visão geral com foco em definições, sintomas, prevalência e etiologia.
MÉTODO Revisamos sistematicamente as bases de dados ERIC, PsyARTICLES, PsycINFO, PSYNDEX, e PubMed para o período de janeiro de 1991 a agosto de 2016, e adicionalmente identificamos referências secundárias.
RESULTADOS A definição proposta pelo Manual Diagnóstico e Estatístico de Desordens Mentais, quinta edição, fornece um bom ponto de partida para diagnosticar DJI, mas traz algumas desvantagens. Desenvolver DJI requer a interação de vários fatores internos como eu deficiente, regulação de humor e recompensa, problemas com tomada de decisões, e fatores externos como suporte familiar e habilidades sociais deficientes. Adicionalmente, fatores específicos relacionados aos jogos podem levar a DJI. Sintetizando o conhecimento etiológico, sugerimos um modelo integrado de DJI para elucidar a relação entre fatores internos e externos.
INTERPRETAÇÃO Até o momento, o conceito de DJI e as vias levando a ela não são inteiramente claros. Em particular, faltam estudos com acompanhamento de longo prazo. A DJI deve ser entendida como uma desordem perigosa, com complexas bases psicossociais.