الجمعية التونسية للعلوم الطبية

LA SOCIÉTÉ TUNISIENNE DES SCIENCES MÉDICALES

LA TUNISIE MEDICALE

Special issue: Septembre 2025

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SYSTEMATIC- REVIEW

Cardiovascular and pulmonary response in Internet gaming disorder: A systematic review

Réponse cardiovasculaire et pulmonaire dans le trouble du jeu vidéo : Une revue systématique

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Abstract

Introduction: Internet Gaming Disorder (IGD) is a behavioral addiction characterized by impaired control over gaming. While its psychological aspects are well-documented, its physiological correlates, particularly those governed by the autonomic nervous system (ANS), are less well-synthesized. Heart rate variability (HRV) and pulmonary function are key indicators of cardiorespiratory health and ANS regulation. This systematic review aimed to evaluate the impact of IGD on chronotropic (as measured by HRV) and ventilatory responses, both at rest and during active gaming.
Methods: We searched PubMed, Embase, and Scopus from database inception to December 2024 seeking for observational studies published in English or French. We included studies that diagnosed IGD using formal criteria (DSM-5/ICD-11) and objectively measured HRV and/or pulmonary function in individuals with IGD compared to healthy controls. Two independent reviewers performed study selection, data extraction, and risk of bias assessment using the ROBINS-I tool.
Results: The search yielded 249 records, from which four case-control studies met the inclusion criteria, comprising 162 participants (77 IGD, 85 controls). The overall risk of bias was judged to be low. At rest (k=3 studies), baseline HRV parameters including the natural logarithm of high-frequency power (lnHF), root mean square of successive differences (RMSSD), and standard deviation of normal-to-normal intervals (SDNN) did not differ significantly between the IGD and control groups. During active gaming (k=2 studies), a blunted parasympathetic reactivity was observed in the IGD group, characterized by a significant drop in lnHF not observed in controls. Regarding pulmonary function (k=1 study), while lung volumes were similar, individuals with IGD showed significantly lower respiratory muscle strength compared to controls.
Conclusion: This review suggested that IGD is associated with preserved tonic autonomic function at rest but impaired phasic parasympathetic reactivity during gaming engagement. Furthermore, IGD may be linked to reduced respiratory muscle strength, potentially indicating a physical deconditioning. These physiological alterations highlight the systemic impact of IGD and may serve as potential biomarkers for diagnosis and monitoring. PROSPERO registration number: CRD42024585778.

Keywords : Adolescent; Autonomic Nervous System; Internet Addiction Disorder; Respiratory Muscles; Young Adult.

Résumé

Introduction: Le trouble du jeu vidéo (TJV) est caractérisé par une perte de contrôle sur la pratique du jeu. Tandis que ses aspects psychologiques sont bien documentés, ses corrélats physiologiques, en particulier ceux régis par le système nerveux autonome (SNA), sont moins bien synthétisés. La variabilité de la fréquence cardiaque (VFC) et la fonction pulmonaire sont des indicateurs clés de la régulation par le SNA. Cette revue systématique visait à évaluer l'impact du TJV sur les réponses chronotropes (VFC) et ventilatoires, au repos et pendant une session de jeu active.
Méthodes: Nous avons interrogé les bases de données PubMed, Embase et Scopus depuis leur création jusqu'à décembre 2024. Nous avons inclus les études qui diagnostiquaient le TJV selon des critères formels (DSM-5/ICD-11) et mesuraient objectivement la VFC et/ou la fonction pulmonaire chez des individus avec TJV par rapport à des témoins sains. La sélection des études, l'extraction des données et l'évaluation du risque de biais en utilisant l'échelle ROBINS-I ont été réalisées par deux auteurs.
Résultats: La recherche a identifié 249 articles, parmi lesquels 4 études cas-témoins ont été incluses, totalisant 162 participants (77 avec TJV, 85 témoins). Le risque de biais a été jugé faible. Au repos (k=3 études), aucune différence significative n'a été observée pour les paramètres de VFC de base (logarithme naturel de la puissance haute fréquence (lnHF), racine carrée de la moyenne des différences successives au carré (RMSSD), et écart-type des intervalles normal-à-normal (SDNN)) entre les groupes. Pendant le jeu actif (k=2 études), une réactivité parasympathique atténuée a été observée dans le groupe présentant un TJV, caractérisée par une baisse significative du lnHF qui n'était pas présente chez les témoins. Concernant la fonction pulmonaire (k=1 étude), les individus avec TJV présentaient une force musculaire significativement plus faible bien que les volumes pulmonaires aient été similaires à ceux des témoins.

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LA TUNISIE MEDICALE-2025; Vol 103 (09): 1218-1226 DOI: 10.62438/tunismed.v103i9.6214

Conclusion: Cette revue a suggéré que le TJV est associé à une fonction autonome préservée au repos, mais à une altération de la réactivité parasympathique pendant le jeu. De plus, le TJV pourrait être lié à une force musculaire respiratoire réduite. Ces altérations soulignent l'impact systémique du TJV et pourraient servir de biomarqueurs pour le diagnostic et le suivi.
Numéro d'enregistrement PROSPERO : CRD42024585778

Mots clés: Adolescent ; Jeune adulte ; muscles respiratoires ; Trouble addictif à l'Internet ; Système nerveux autonome.

Introduction

Internet Gaming Disorder (IGD) is a behavioural addiction marked by loss of control over gaming, prioritising it over daily activities, and continuing despite negative consequences[1]. It was listed in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM-5) as a condition for further study [1] and since 2019, IGD has been recognised as a disorder in the 11th revision of the International Classification of Diseases (ICD-11) [2].The prevalence of IGD in adolescents varies widely, from 1.16% in Germany [3] to over 17% in China [4], with prevalence rates increasing by a factor of 1.6 among young adult during the the Coronavirus Disease 2019 pandemic [5]. IGD is increasingly recognized as a complex condition with significant neurobehavioral underpinnings [6]. It often co-occurs with psychiatric disorders like depression, anxiety, and attention deficit hyperactivity disorder [6], and shares core neurobehavioral patterns with substance use disorders [7]. This progression toward addiction is strongly linked to a decline in cognitive control that facilitates the shift from goal-directed to compulsive gaming [8,9].
However, despite this well-documented psychopathological complexity, its formal inclusion in the DSM-5 relies on a diagnosis based exclusively on behavioural criteria, overlooking any objective physiological markers [10]. This limitation underscores the need to explore the somatic manifestations of the disorder. This gap directs attention toward the autonomic nervous system (ANS), which connects the brain's executive functions to the body's physiological state. A key non-invasive marker of ANS function is Heart Rate Variability (HRV), reflecting the balance between sympathetic and parasympathetic activity and relating to stress and cognitive flexibility [11]. Emerging evidence has linked IGD to altered HRV patterns, suggesting potential deficits in executive control and stress regulation [12,13]. Alongside cardiac metrics, the ventilatory response is another critical parameter reflecting ANS activity [14], yet it remains poorly assessed in the context of IGD.
To clarify these physiological changes, this systematic review aimed to synthesize the evidence on HRV and pulmonary function during both rest and active gaming, thereby evaluating the impact of IGD on chronotropic and ventilatory responses.

Methods

Protocol and Reporting

This systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [15]. The review protocol was prospectively registered in the PROSPERO international register of systematic reviews (registration number: CRD42024585778), and a detailed account of the methodology has also been published [16].

Eligibility Criteria

Studies were included based on the Population, Intervention (Exposure), Comparison, and Outcome (PICO) framework:
Population (P): Individuals with a formal diagnosis of IGD according to the DSM-5 or the ICD-11 [1,2].
Exposure (I): The presence of IGD.
Comparison (C): Individuals without IGD, such as healthy controls or non-problematic gamers.
Outcomes (O): At least one objective measure of cardiovascular or pulmonary function. Primary outcomes of interest were HRV parameters (specifically High-Frequency power [HF], Root Mean Square of Successive Differences [RMSSD], and Standard Deviation of NN intervals [SDNN]) and secondary outcome was pulmonary function.
Inclusion criteria encompassed observational study designs, such as case-control and cohort studies, published in English or French. Exclusion criteria included case reports, narrative reviews, conference abstracts, and studies lacking objective, quantitative measurements of the outcomes of interest.
We made a minor deviation from the prospectively registered protocol to the pre-specified age criterion. While we initially defined the population as aged 12 years and older to target adolescents, we lowered the threshold to 10 years. This post-hoc amendment was made because the initial cutoff was deemed unnecessarily restrictive as it would have excluded key evidence on younger children and adolescents.

Information Sources and Search Strategy

A systematic literature search was conducted across three electronic databases: PubMed, Scopus, and Embase from database inception to December 2024. The search was supplemented by manually screening the reference lists of included articles and relevant reviews to identify additional studies (backward and forward citation tracking). The complete, database-specific search strategies are detailed in Appendix 1.

Selection Process

The study selection process was performed in two stages by two independent authors. In the first stage, titles and abstracts of all identified records were screened for potential relevance. In the second stage, the full texts of the potentially relevant articles were retrieved and assessed against the predefined eligibility criteria. Any disagreements between the two reviewers at either stage were resolved through discussion and, if necessary, adjudicated by a third author to reach a consensus.

Data Extraction Process

Two authors independently extracted data from the included studies using a standardized data extraction form developed in Microsoft Excel. The extracted data included:

Study Characteristics: Author, year of publication, study design.

Participant Characteristics: Sample size, age, and sex distribution for both IGD and control groups; diagnostic criteria for IGD.

Methodological Details: The experimental conditions under which outcomes were measured (e.g., at rest, during active gaming).

Outcome Data: Quantitative results for HRV and respiratory parameters, reported as mean, standard deviation (SD), and sample size (N) for each group. The corresponding p-values for the between-group comparisons were also extracted when available. To quantify the magnitude of observed differences, we extracted reported effect sizes (e.g., partial eta-squared [$\eta^2 p$], Cohen's d). When not reported, Cohen's d was calculated from the provided means, standard deviations, and sample sizes using a validated web-based tool[17].

We attempted to contact the authors of one study via email for missing or unclear data, but no additional information was obtained.

Study Risk of Bias Assessment

The methodological quality and risk of bias of each included study were independently assessed by two authors using the Risk Of Bias In Non-randomised Studies (ROBINS-I) tool [18]. This tool evaluates bias across seven domains: (1) confounding, (2) selection of participants, (3) classification of exposures, (4) deviations from intended exposures, (5) missing data, (6) measurement of outcomes, and (7) selection of the reported result. Each domain was judged to be at a low, moderate, serious, or critical risk of bias, leading to an overall judgment of the risk of bias for each study. Disagreements were resolved by consensus.

Synthesis of Results

A quantitative synthesis of the results using meta-analysis was initially planned. It was pre-specified that this approach would only be pursued if a sufficient number of clinically and methodologically homogeneous studies were identified. In the event of substantial heterogeneity or an insufficient number of eligible studies, a narrative synthesis would be performed instead.

In such a case, this narrative synthesis would be structured by outcome domain (HRV and pulmonary function) and by experimental condition (at rest and during gaming). The synthesis would focus on comparing the direction, magnitude, and statistical significance of effects across studies to identify consistent patterns and gaps in the literature. For this purpose, data on effect measures as reported in the original studies (e.g., mean differences and p-values from independent t-tests or ANOVAs) were to be extracted and presented.

Results

Study Selection

The study selection process is illustrated in the PRISMA flow diagram (Figure 1). A total of 246 articles were initially identified through database searches, and 3 additional records were retrieved from citation research. After removing duplicates, 172 records remained for title and abstract screening, resulting in the exclusion of 143 clearly irrelevant publications.

The remaining 29 full-text articles were assessed for eligibility. Of these, 21 were excluded for the following main reasons: 8 studies did not meet the diagnostic criteria for IGD, as diagnoses were based solely on self-reported screening tools rather than clinical interviews based on DSM-5 criteria; 4 studies did not report HRV, which was a required outcome measure; 4 studies were excluded due to duplicate data, as they analyzed the same participant cohorts as other included studies; The full list of excluded studies with reasons is provided in Appendix 2. Ultimately, four studies met all inclusion criteria and were included in the final narrative synthesis

Characteristics of Included Studies

The key characteristics of the included studies are summarized in Table 1. All studies were cross-sectional case-control designs conducted between 2018 and 2023. A total of 162 participants were included, comprising 77 individuals with IGD and 85 healthy controls. Among the four included studies, three involved predominantly young adult males, with a mean age ranging from 22 to 23 years. The remaining study focused on adolescents, with a mean age of 14 years. The severity of IGD was assessed using validated scales (Internet Addiction Test (IAT) or Young's IAT (Y-IAT)), with reported mean scores for the IGD groups ranging from 51.4 to 64.6, confirming that the included samples exhibited a clinically significant level of the disorder.

Table 1. General Characteristics of Included Studies

Study	Country	Design	IGD (n)	Control (n)	Age (mean ± SD)	Gender ratio	Diagnostic Tool	Severity (mean ± SD)	Gaming Context	Rest Duration (min)	Gaming Measurement Duration (min)
Park et al. [19]	South Korea	Case-control	53	61	23.7 ± 5.0 / 25.0 ± 3.4	50M/3F 52M/9F	DSM-5	63.66 ±15.27	N/A (resting-state measurements	5	N/A
Lee et al. [12]	South Korea	Case-control	33	29	23.1 ± 2.8 / 22.0 ± 2.8	33M/0F 29M/0F	DSM-5 + IAT ≥ 50	64.6 ± 8.3	MOBA (LoL)	5	5
Hong et al. [13]	South Korea	Case-control	21	27	22.3 ± 2.9 / 21.8 ± 2.8	21M/0F 27M/0F	DSM-5 + Y-IAT > 50	63.1 ± 8.8	MOBA (LoL)	5	consecutive 5-minute intervals
Mutlu et al. [20]	Turkey	Case-control	64	41	14.0 ± 1.8 / 14.4 ± 1.3	Not reported	DSM-5	51.44± 13.05	N/A (clinical measurements)	N/A	N/A

DSM : Diagnostic and Statistical Manual of Mental Disorders ; **IGD** : Internet Game Disorder ; **LOL** : League of Legends ; **min** : minute ; **MOBA** : Multiplayer Online Battle Arena ; **N/A**: Non Applicable ; **SD** : Standard Deviation

The primary outcomes were standard HRV parameters, including the natural logarithm of high-frequency power (lnHF), the root mean square of successive differences (RMSSD), and the standard deviation of normal-to-normal intervals (SDNN). These parameters were measured under two main conditions: at rest ("Rest") and during an active video gaming session ("Gaming"). The study by Park et al.[19] only reported data for the "Rest" condition.

Risk of Bias Within Studies

The risk of bias for each included study was assessed using the ROBINS-I tool [17], with a detailed summary provided in Table 2.

Overall, all four studies were judged to have a low risk of bias, reflecting a methodologically sound body of evidence. The included studies demonstrated strengths in several domains. The risk of bias due to confounding (D1) was consistently low, as studies generally controlled for key demographic variables like age and sex. Similarly, the risks were low for measurement of outcomes (D6), given the objective nature of physiological recordings, and for selective reporting (D7), suggesting that authors reported their pre-specified outcomes.

However, some domains presented a moderate risk of bias, warranting careful consideration. For the selection of participants (D2), a moderate risk was identified in two studies due to their recruitment strategies. Park et al.[19] recruited a clinical sample for the IGD group versus a community sample for controls, a mismatch that can introduce selection bias. Hong et al.[13] utilized convenience sampling (e.g., flyers and online ads), which may limit the generalizability of their findings. A moderate risk was also noted for the classification of exposure (D3) in Mutlu et al.[20], as the study did not specify the use of a standardized clinical interview for the diagnosis of IGD. Finally, a moderate risk for deviations from intended exposures (D4) was identified, likely stemming from protocols where participants subjectively identified periods of "high" or "low" attention post-gameplay (e.g., Hong et al.[13]), introducing a lack of standardization in the experimental task.

Despite these specific limitations, no study was rated at a serious or critical risk of bias in any domain, supporting the overall reliability of the evidence included in this review.

Table 2. Risk of bias table

Domains of bias	Park et al. [18]	Lee et al. [12]	Hong et al. [13]	Multu et al. [19]
D1 : Confounding	L	L	L	L
D2 : Selection of participants	M	L	M	L
D3 : Exposure classification	L	L	L	M
D4 : Deviation from intended exposures	L	M	L	L
D5 : Missing Data	L	L	L	L
D6 : Outcomes measurement	L	L	L	L
D7 : Selection reported results	L	L	L	L
Overall judgment of the risk of bias	Low	Low	Low	Low

L : Low; **M** : Moderate

Synthesis of Results

Due to the small number of included studies, a meta-analysis was not performed. A narrative synthesis of the findings is presented below, organized by experimental condition.

Heart Rate Variability at Rest (k = 3 studies)

A detailed breakdown of the primary outcomes is presented in Table 3. All three included studies reported HRV parameters at rest. A consistent pattern emerged across the studies: no statistically significant differences were found in baseline HRV between individuals with IGD and healthy controls.

Parasympathetic Indices (lnHF and RMSSD): Park et al.[19], Lee et al.[12], and Hong et al.[13] all reported similar baseline values for lnHF and RMSSD between the IGD and control groups. Although minor numerical differences were present, none reached statistical significance in the individual studies.

Overall Variability (SDNN): Similarly, no significant group differences were observed for SDNN, a measure of total HRV, in any of the three studies [12,13,19]. This suggests that at rest, the tonic autonomic regulation, particularly vagal tone, may not be significantly altered in young adult males with IGD compared to their healthy peers.

Table 3. Heart Rate Variability (HRV) Results at Rest and During Gaming

Author	Rest lnHF (IGD) (mean ± SD)	Rest lnHF (Control) (mean ± SD)	P	Rest RMSSD (IGD) (mean ± SD)	Rest RMSSD (Control) (mean ± SD)	P	Rest SDNN (IGD) (mean ± SD)	Rest SDNN (Control) (mean ± SD)	P	Gaming lnHF (IGD) (mean ± SD)	Gaming lnHF (Control) (mean ± SD)	P	Gaming RMSSD (IGD) (mean ± SD)	Gaming RMSSD (Control) (mean ± SD)	P	Gaming SDNN (IGD) (mean ± SD)	Gaming SDNN (Control) (mean ± SD)	P
Park et al. [19]	4.51± 0.84	4.57± 0.53	0.344	41.61 ± 28.39	43.8 ± 23.2	0.239	39.73 ± 19.44	41.59 ± 18.17	0.117	N/A	N/A		N/A	N/A		N/A	N/A	
Lee et al. [12]	4.63 ± 0.96	4.20 ± 0.90	0.073	42.95 ± 26.24	32.64 ± 21.75	0.1	39.85 ± 18.72	33.87 ± 16.57	0.191	4.15 ± 0.093	4.12 ± 0.37	0.896	36.39 ± 21.19	34.51 ± 17.46	0.707	35.03 ± 15.55	35.71 ± 14.24	0.934
Hong et al. [13]	4.7 ± 0.7	4.3 ± 0.9	0.079	40.7 ± 19.5	35.3± 22.2	0.387	50.3 ± 14.5	45.3 ± 22.8	0.386	4.2 ± 0.7	4.3 ± 0.8	0.535	31.2 ± 12.7	35.7 ± 16.7	0.311	44.6 ± 13.3	47.7 ± 16.6	0.493

IGD: internet gaming disorder, **lnHF**: natural logarithm of high-frequency power, **N/A**: Non Applicable ; **RMSSD**: root mean square of successive differences, **SDNN**: standard deviation of normal-to-normal intervals ; **SD** : Standard Deviation

Heart Rate Variability During Active Gaming (k = 2 studies)

Two studies [12,13] provided data on HRV during an active gaming session.

Absolute HRV Values: Consistent with the findings at rest, the synthesis of these two studies indicates no significant differences in the absolute values of HRV parameters (lnHF, RMSSD, SDNN) between the IGD and control groups during the gaming task.

HRV Reactivity: Importantly, both studies highlighted that the critical difference may lie not in the absolute values, but in the reactivity of the autonomic nervous system. Hong et al.[13] explicitly found a significant interaction effect for both lnHF ($p = 0.043$) and RMSSD ($p = 0.028$). This was supported by a medium effect size ($\eta^2p = 0.052$ for lnHF), indicating that the IGD group exhibited a significant reduction in lnHF from baseline to high-attention gaming periods, a change not observed in the control group. Similarly, Lee et al.[12] reported a significantly greater drop in lnHF in the IGD group compared to controls ($p = 0.014$), a finding underscored by a calculated medium-to-large effect size (Cohen's $d = -0.64$). These findings suggest that while individuals with IGD have a normal autonomic function at rest, they show a weaker or dysfunctional parasympathetic response when facing the cognitive and emotional demands of gaming. This altered "on-the-spot" (phasic) reaction, rather than a constant (tonic) impairment, appears to be a more defining characteristic of the disorder

Pulmonary Function and Respiratory Muscle Strength (k = 1 study)

Regarding the pulmonary component of this review, only one study, Mutlu et al.[20] met the inclusion criteria and reported data on respiratory function. This study assessed standard spirometric lung volumes and respiratory muscle strength at rest in a population of children and adolescents with IGD.

The findings on lung volumes were not statistically significant. While the IGD group showed numerically lower mean values for Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1) compared to healthy controls, the authors reported that these differences did not reach statistical significance ($p=0.47$ and $p=0.16$, respectively).

In contrast, the study revealed a significant impairment in respiratory muscle strength. As detailed in Table 4, the IGD group exhibited significantly lower Maximum Inspiratory Pressure (MIP) and Maximum Expiratory Pressure (MEP) than the control group. The magnitude of these differences was notable, corresponding to a medium effect size for MIP (Cohen's $d = -0.59$) and a large effect size for MEP (Cohen's $d = -0.74$). These results indicate a potential deficit in the strength of the primary respiratory muscles, such as the diaphragm and intercostal muscles, in adolescents with IGD.

Notably, none of the studies included in this systematic review, including Mutlu et al.[20], reported data on respiratory rate (RR).

Table 4. Pulmonary Function at Rest

Author (Year)	RR	FVC (litre) (IGD) Mean ± SD	FVC (litre) (Control) Mean ± SD	p value	FEV1 (litre) (IGD) Mean ± SD	FEV1 (litre) (Control)	p value	MIP (cmH2O) (IGD) Mean ± SD	MIP (cmH2O) (Control) Mean ± SD	p value	MEP (cmH2O) (IGD) Mean ± SD	MEP (cmH2O) (Control) Mean ± SD	p value
Mutlu et al. [20]	NR	3.70 ± 0.92	3.85 ± 1.03	0.47	3.27 ± 0.80	3.51 ± 0.78	0.16	78.22 ± 17.44	91.86 ± 29.97	0.005	88.50 ± 23.70	107.35 ± 27.68	p < 0.001

FVC: forced vital capacity, **FEV1**: forced expiratory volume in one second, **IGD**: internet gaming disorder, **MIP**: maximum inspiratory pressure, **MEP**: maximum expiratory pressure

Discussion

Summary of Evidence

Despite a comprehensive search yielding 249 articles, only four studies met the strict inclusion criteria, which required a DSM-5-based diagnosis of IGD and objective assessment of HRV and/or respiratory function. The results indicate that while baseline autonomic function at rest appears preserved, individuals with IGD may demonstrate blunted parasympathetic reactivity during gaming tasks, as well as reduced respiratory muscle strength, particularly among adolescents.

Interpretation in Context

At rest, HRV parameters (lnHF, RMSSD, and SDNN) did not significantly differ between IGD participants and healthy controls across the included studies. This suggests that tonic autonomic regulation may remain intact in individuals with IGD under baseline conditions. However, during active gaming, two studies reported a reduced parasympathetic response in the IGD group [12,13]. A significant drop in lnHF during high-attention gaming was observed in IGD participants but not in controls, indicating a possible dysfunction in phasic autonomic modulation.

Previous research has shown that excessive and compulsive Internet use is associated with heightened emotional reactivity and difficulties in self-regulation, which may reflect underlying autonomic nervous system dysregulation [21]. In parallel, neuroscientific studies have demonstrated that the autonomic nervous system is tightly integrated with affective and cognitive processing, and that disruption of this integration can impair adaptive physiological responses to emotional or cognitive demands [22]. Recent neurophysiological data from intracerebral recordings further support the concept of a centralized control of cardiac activity, revealing how specific cortical and subcortical structures modulate autonomic output through complex neural networks [23]. These insights provide a mechanistic basis for understanding how behavioral addictions such as IGD—via their impact on emotion, reward, and executive circuits—may result in altered cardiovascular regulation. Taken together, derived from a set of studies with an overall low risk of bias, these findings suggest that IGD may involve normal resting autonomic function but an inflexible or inappropriate autonomic response during cognitive-emotional engagement, such as gaming. This may represent a physiological signature of the disorder.

Regarding ventilatory parameters, only one study within the present review specifically investigated respiratory function in participants with IGD [20]. Standard spirometric values such as FVC and FEV_1 were not significantly different between the IGD and control groups. However, significant alterations were observed in respiratory muscle strength: both maximal inspiratory pressure and maximal expiratory pressure were substantially lower in the IGD group. These findings suggest a reduction in respiratory muscle performance, potentially due to a combination of sedentary lifestyle, postural abnormalities, and reduced engagement in physical activity frequently associated with prolonged gaming behavior. The same study also reported lower physical activity scores and higher rates of fatigue and musculoskeletal complaints in the IGD group, supporting the interpretation that physical deconditioning may underlie the observed respiratory muscle weakness. This raises concerns about long-term health risks, particularly in adolescents whose respiratory and musculoskeletal systems are still maturing. These findings are consistent with prior research by Alonazi et al., who assessed the effects of smartphone addiction on pulmonary function in children [24]. Their study revealed that excessive smartphone use was associated with reduced FVC, FEV_1, and Peak Expiratory Flow (PEF) compared to non-addicted peers, even after adjusting for BMI and activity level. The authors attributed these impairments to chronic poor posture, shallow breathing patterns, and physical inactivity, factors which are also prevalent among adolescents with excessive gaming behavior. Together, these studies suggest that screen-based behavioral addictions—including IGD and smartphone overuse—may negatively impact not only respiratory muscle strength but also lung volumes, especially in younger populations. The lack of significant differences in basic spirometric indices in the Mutlu study may reflect early-stage or subclinical impairments, or limitations of spirometry in capturing functional decline in respiratory musculature. These observations underscore the need for comprehensive respiratory assessments, including dynamic measures and physical activity monitoring, in youth presenting with screen-related behavioral addictions.

Limitations

This review has several limitations. First, only four studies were included, which limits both the statistical power and the external validity of the findings. A potential publication bias remains a key concern; due to the small number of studies, this bias could not be formally assessed. It is possible that studies reporting non-significant results were not published, which may have influenced the overall conclusions drawn from the available literature. Additionally, all included studies had a cross-sectional design, preventing any causal inferences. The sample sizes were small and predominantly consisted of young adult males. Finally, a meta-analysis was not feasible due to the limited number of studies.

Clinical and Scientific Implications

The findings of this review reinforce the notion that IGD may extend beyond psychological and behavioral manifestations to include physiological alterations, particularly in autonomic reactivity and respiratory muscle performance. These impairments could have long-term health implications, especially in adolescents and young adults. Clinicians managing IGD should consider including basic physiological assessments (e.g., heart rate, blood pressure, respiratory strength) as part of a comprehensive clinical evaluation. Furthermore, these physiological signs may serve as biomarkers of severity or targets for intervention, particularly in individuals with signs of physical deconditioning.

These findings align with the growing recognition of IGD as a condition with measurable biological correlates. A recent narrative review by Skok and Waszkiewicz highlights a range of emerging biomarkers for IGD, including alterations in autonomic nervous system regulation, hormonal responses, and neuroimaging patterns [25]. This reinforces the view that cardiorespiratory metrics, such as HRV and respiratory muscle strength, may contribute to a multimodal biomarker framework for IGD, supporting both diagnosis and treatment monitoring.

Future Research Directions

Given the preliminary yet methodologically sound nature of the current evidence, future research should aim to expand on these findings through several key directions. Studies should incorporate objective and standardized physiological measurements, including electrocardiography, HRV analysis under stress, blood pressure, respiratory pressures, peripheral flows, static lung volumes, and cardiopulmonary exercise testing. It is also essential to include larger and more diverse samples, stratified by age, sex, and pubertal status, to improve the generalizability of results. Longitudinal or interventional study designs are recommended to better understand causal mechanisms and recovery trajectories. Furthermore, future research should explore the influence of contextual variables such as gaming frequency, duration, time of day, and sleep quality. Finally, assessing the effectiveness of therapeutic interventions—such as psychotherapy or physical activity—on autonomic and ventilatory function could provide valuable insights for clinical practice. Moreover, it is essential that future research assess cardiac and respiratory responses at multiple time points to better reflect the dynamics of autonomic regulation. Specifically, measurements should be taken at rest (baseline), during the initial phase of gaming (acute exposure), and after prolonged gaming sessions (e.g., one or more hours). This approach would allow for the identification of initial autonomic reactivity, early adaptation or habituation, and cumulative physiological fatigue. Such designs may help distinguish between transient and persistent physiological alterations in individuals with IGD.

Conclusion

Although limited by a small number of studies and methodological heterogeneity, this systematic review suggests that IGD may be associated with impaired autonomic reactivity and reduced respiratory muscle strength, particularly in youth. These findings highlight the need for greater clinical attention to the somatic consequences of IGD and call for further interdisciplinary research to elucidate its physiological underpinnings.

Abbreviations
ANS: Autonomic Nervous System
DSM-5: Diagnostic and Statistical Manual of Mental Disorders, 5th Edition
FEV_1: Forced Expiratory Volume in one second
FVC: Forced Vital Capacity
HRV: Heart Rate Variability
IAT: Internet Addiction Test
ICD-11: International Classification of Diseases, 11th Revision
IGD: Internet Gaming Disorder
lnHF: Natural Logarithm of High-Frequency Power
MEP: Maximum Expiratory Pressure
MIP: Maximum Inspiratory Pressure
PICO: Population, Intervention, Comparison, and Outcome
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RMSSD: Root Mean Square of Successive Differences
ROBINS-I: Risk Of Bias In Non-randomised Studies
SDNN: Standard Deviation of Normal-to-Normal Intervals

Declaration
The authors acknowledge the use of Google AI Studio on July 25, 2025, for the sole purpose of enhancing the manuscript's grammar, clarity, and adherence to academic English conventions. All AI-generated suggestions were manually reviewed and implemented at the authors 'manuscript. The authors retain full and final responsibility for all content within this publication.

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