



Relationship between Internet Addiction and Physical Activity Participation in Adolescents: The Chain Mediating Role of Sleep Disruption and Fatigue

Rezvaneh Makki *

Department of Sport Sciences, Faculty of Humanities, University of Magdeburg, Germany.

*Corresponding Author: Rezvaneh Makki, Department of Sport Sciences, Faculty of Humanities, University of Magdeburg, Germany. Email: rezvaneh.makki@ovgu.de

Received: 28 December, 2025; Revised: 03 December, 2025; Accepted: 14 December, 2025; Published: 26 December, 2025.

Abstract

Introduction: The relationship between Internet addiction (IA) and participation in physical activity (PA) among youth is well recognized; however, the specific mechanisms that drive this connection have not been thoroughly examined in the current body of research.

Objective: This study aims to delve into the mediating roles of sleep disruption and fatigue, which may serve as critical pathways linking IA to reduced PA in adolescents.

Methods: This cross-sectional study utilized a sample of 389 adolescents (13-17 years), selected through convenience sampling. The IAT, PAS, PSQ and FIS were implemented to measure the research variables. Data analysis was performed using the PROCESS macro (Model 6).

Results: IA serves as a significant negative predictor of PA ($\beta=-0.452$). Furthermore, IA positively correlates with sleep disruption ($\beta=0.226$), which in turn negatively impacts PA ($\beta=-0.143$). Additionally, IA is associated with increased fatigue ($\beta=0.364$), and this fatigue also negatively influences PA ($\beta=-0.151$). Finally, both sleep disruption and fatigue fully mediate the relationship between IA and PA ($\beta=0.339$).

Conclusion: A recommended strategy is to implement school-based programs that combine digital literacy and screen-time management with sleep education and structured PA, aiming to reduce internet overuse, improve sleep quality, alleviate fatigue, and consequently increase adolescents' engagement in PA.

Keywords: Adolescent, Exercise, Internet, Sleep, Fatigue

How to Cite: Makki R. Relationship between Internet Addiction and Physical Activity Participation in Adolescents: The Chain Mediating Role of Sleep Disruption and Fatigue. Phys. Act. Child. 2025;2(2):28-33. doi: 10.22034/pach.2025.549827.1071

1. Introduction

Since the mid-twentieth century, the global proliferation of the Internet has significantly transformed various facets of human life. It has evolved into a ubiquitous public resource, accessible to individuals from diverse backgrounds (1). This widespread availability has notably benefited many, particularly students, by enhancing educational opportunities and facilitating social connections (2). Students engage with the Internet through a variety of devices, including computers, laptops, tablets, and smartphones, which have become integral to their learning processes. However, the extensive use of the Internet among youth has given rise to a concerning trend known as IA in recent years (3). Recent data indicates that around 36.7% of individuals worldwide are grappling with IA, a condition that manifests in varying degrees of severity. Specifically, 33.9% of the population is classified as experiencing moderate addiction, while a smaller segment, comprising 2.8%, suffers from severe IA. Notably, adolescents aged 13 to 17 are particularly vulnerable, with an alarming 73% of this age group showing signs of addiction to the

Internet (4). This statistic underscores the pressing need for awareness and intervention strategies aimed at mitigating the risks associated with excessive Internet use among teenagers, who are increasingly reliant on digital platforms for social interaction, education, and entertainment.

While the Internet itself serves as a neutral tool, its excessive and inappropriate use poses the risk of developing addictive behaviors (5). The impact of cyberspace and the Internet on human life and experiences is profound, prompting researchers to investigate the adverse consequences associated with pathological and addictive usage of this relatively new technology (6). Numerous scholars, medical professionals, and mental health experts are increasingly recognizing the detrimental psychological effects associated with excessive Internet use and engagement in cyberspace, which have emerged as significant global concerns (7,8). This phenomenon is characterized by a range of pathological behaviors, including an obsessive preoccupation with online activities, an intense craving for Internet access, and a noticeable decline in the ability to function effectively in daily life.



Individuals may experience social isolation as they withdraw from real-world interactions, develop a tolerance that necessitates greater amounts of online engagement to achieve satisfaction, and ultimately lose control over their usage patterns (9,10). These factors contribute to a cycle of negative consequences, where the individual becomes increasingly aware of the adverse effects of their online habits yet feels powerless to change their behavior, leading to a profound sense of psychological distress and dysfunction (11).

Physical activity (PA) is essential for students as it aids in the development of vital skills, improves fitness, enhances knowledge, and cultivates positive attitudes, all of which contribute significantly to their overall growth and well-being (12,13). It serves as a foundation for promoting physical and mental health among youth (14,15). In contemporary society, PA has emerged as a significant instrument for governments, enabling them to steer populations toward specific objectives, as the sports industry has become a primary avenue for public education (12). However, despite the numerous advantages associated with PA, there is a troubling trend of declining interest among youth in engaging with PA, both within school settings and during their leisure time (14,15). One of the key factors contributing to this waning enthusiasm is the excessive use of the Internet, which often leads to addiction and distracts school-students from pursuing PA (16,17). This shift in focus not only undermines the potential benefits of PA but also poses challenges for educators and policymakers aiming to promote a healthier, more active lifestyle among the youth.

Young individuals who engage in regular PA tend to show less inclination towards sedentary pursuits, such

as prolonged Internet usage. Research has shown that prolonged engagement with computers and the Internet can result in a range of negative physical health effects (18-20). The excessive time individuals spend online has led to a notable decline in PA and an increase in sedentary lifestyles. Research has identified a correlation between reduced PA and heightened sedentary behavior as significant risk factors for IA (21,22). A particular study highlighted that individuals who engage in minimal PA tend to exhibit higher average scores on measures of IA (24). This suggests that promoting increased PA could serve as an effective strategy to mitigate the severity of IA. By encouraging individuals to incorporate more movement into their daily routines, it may be possible to foster healthier habits that counteract the negative impacts of excessive Internet use.

The relationship between IA and participation in PA among youth is well recognized; however, the specific mechanisms that drive this connection have not been thoroughly examined in the current body of research. This study aims to delve into the mediating roles of sleep disruption and fatigue, which may serve as critical pathways linking IA to reduced PA in adolescents. By focusing on these mediators, the research seeks to clarify how IA can lead to sleep disturbances and increased fatigue, ultimately impacting the likelihood of engaging in PA. The main aim of this study is to clarify the relationship between IA and PA among adolescents, while also examining how sleep disruption and fatigue may sequentially mediate this relationship. A conceptual model outlining these relationships is presented in Figure 1, providing a visual representation of the hypothesized pathways involved in this complex interplay.

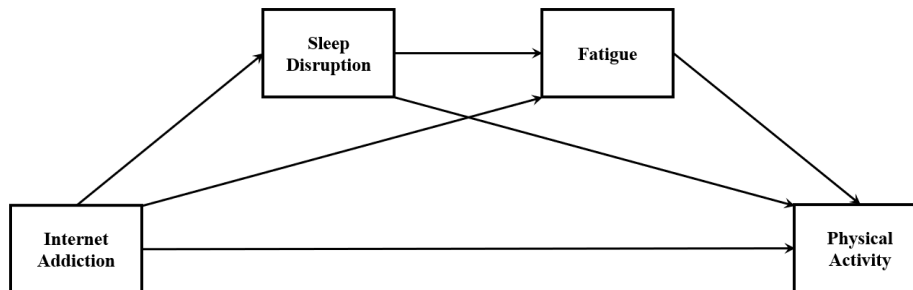


Figure 1. The Theoretical Model of the Study.

2. Methods

2.1. Design and Participants

This research employed a descriptive-correlational design and utilized structural equation modeling to analyze data from a sample of 389 adolescents aged 13 to 17 years. Participants were recruited from various middle and high schools, with the requirement that they had no pre-existing physical or mental health conditions. Those who did not meet these criteria or who failed to complete the questionnaire were excluded to maintain data integrity. A priori power analysis conducted with G*Power 3.1 ($f^2 = 0.15$, $\alpha=0.05$, power=0.80) with three predictors, indicated that a minimum sample size of 77 participants was necessary. The final sample of 389 adolescents significantly surpassed this threshold, ensuring sufficient statistical power for detecting medium-sized effects in the mediation analyses.

2.2. Measurement

2.2.1. Internet Addiction

The Internet Addiction Test (IAT) was utilized for evaluating IA (24). The IAT comprises 20 items that are evaluated from 1 (rarely) to 5 (always). A score of 50 or higher is considered indicative of potentially problematic internet use, while a score of 80 or above suggests a more severe, pathological level of addiction. In this study, the Cronbach's alpha coefficient was 0.91.

2.2.2. Physical Activity

The assessment of PA was conducted utilizing the Physical Activity Scale (25). This scale comprises three key components: intensity, duration, and frequency of physical activity. Each component is categorized into

five distinct levels, with intensity and frequency rated on a scale from 1 to 5, while duration is measured from 0 to 4. To calculate the overall PA score, the individual scores for each component are multiplied together, resulting in a composite score that reflects PA; higher scores correspond to greater levels of activity. In the present study, the Cronbach's alpha was 0.89.

2.2.3. Sleep Disruption

Pittsburgh Sleep Quality Questionnaire (PSQI) was utilized to evaluate participants' sleep disruption (26). Each question within these categories is scored on a scale from zero to three, yielding a total that ranges from 0 to 21, with scores exceeding five indicating poor sleep quality. In this study, the Cronbach's alpha coefficient was 0.85.

2.2.4. Fatigue

The Modified Fatigue Impact Scale (MFIS) was employed to assess fatigue levels (27). The MFIS captures fatigue experiences over the preceding four weeks, yielding a total score that ranges from 21 to 105. A higher score indicates a more significant detrimental effect of fatigue on an individual's daily functioning. In this study, the Cronbach's alpha coefficient was 0.95.

2.3. Statistical Analysis

Descriptive statistics included mean and standard deviation (SD). Additionally, the Pearson correlation test was utilized to explore the relationships among the research variables. The PROCESS macro (Model 6) in SPSS was applied to examine the connections between IA and PA in adolescents, focusing on the mediating roles of sleep disruption and fatigue ($\alpha=0.05$). We performed 5000 bootstrap resampling iterations to improve the model's fit and to derive 95% confidence intervals, thereby enhancing the robustness of the analysis.

3. Results

The demographic assessment indicated that the mean age of the children participating in the study was 15.84 years, accompanied by a SD of 1.21 years, suggesting a relatively homogeneous age group. In terms of physical health, the participants exhibited a body mass index (BMI) that fell within a normal and healthy range, with an average BMI of 18.63 and a SD of 1.30, reflecting a consistent level of body weight relative to height among the subjects. The analysis of skewness and kurtosis for all variables measured yielded values ranging from -2 to +2, thereby confirming that the data conforms to the assumptions of normal distribution, which is essential for the validity of subsequent statistical analyses (Table 1).

Table 1. Description of Research Variables.

	Mean	SD	Skewness	Kurtosis
Internet Addiction	68.97	6.28	0.327	0.472
Physical Activity	17.49	2.74	0.253	0.419
Sleep Disruption	11.92	1.82	0.139	0.271
Fatigue	63.37	5.81	0.427	0.487

In addition, there was a significant negative correlation was identified between IA and PA ($p<0.001$). Conversely, IA exhibited a positive correlation with both sleep disruption and fatigue ($p<0.001$). Furthermore, the analysis uncovered significant

negative correlations between sleep disruption and PA as well as between fatigue and PA ($p<0.001$). Additionally, a positive correlation was found between sleep disruption and fatigue ($p<0.001$) (Table 2).

Table 2. Pearson Correlation matrix among the Research Variables

	1	2	3	4
1. Internet addiction	-			
2. Physical activity	$r=-0.719$ $p<0.001$	-		
3. Sleep disruption	$r=0.608$ $p<0.001$	$r=-0.501$ $p<0.001$	-	
4. Fatigue	$r=0.678$ $p<0.001$	$r=-0.539$ $p<0.001$	$r=0.563$ $p<0.001$	-

The analysis presented in Table 3 and illustrated in Figure 2 demonstrates that, after accounting for gender, IA serves as a significant negative predictor of PA among adolescents ($\beta=-0.452$). Furthermore, the mediation model indicates that IA positively correlates with sleep disruption ($\beta=0.226$), which in turn negatively impacts PA ($\beta=-0.143$). Additionally, IA is associated with increased fatigue ($\beta=0.364$), and this

fatigue also negatively influences adolescent PA ($\beta=-0.151$). Notably, the findings suggest that both sleep disruption and fatigue fully mediate the relationship between IA and PA ($\beta=0.339$). The extent of variance accounted for by these mediation pathways is further elaborated in Table 4, providing a comprehensive understanding of the interplay between these variables.

Table 3. Test of Mediation Model.

Outcome Variable	Predictor Variable	β	SE	t-Value	R ²	F-Value
Physical Activity	Gender	0.049	0.046	1.063	0.287	39.475
	Internet addiction	-0.452	0.042	-10.857		
	Sleep disruption	-0.143	0.043	-3.482		
	Fatigue	-0.151	0.047	-3.214		
Fatigue	Gender	0.012	0.040	0.011	0.036	10.268
	Internet addiction	0.364	0.045	3.726		
	Sleep disruption	0.339	0.043	7.485		
	Gender	0.032	0.045	0.025		
Sleep Disruption	Gender	0.032	0.045	0.025	0.146	20.392
	Internet addiction	0.226	0.045	5.417		

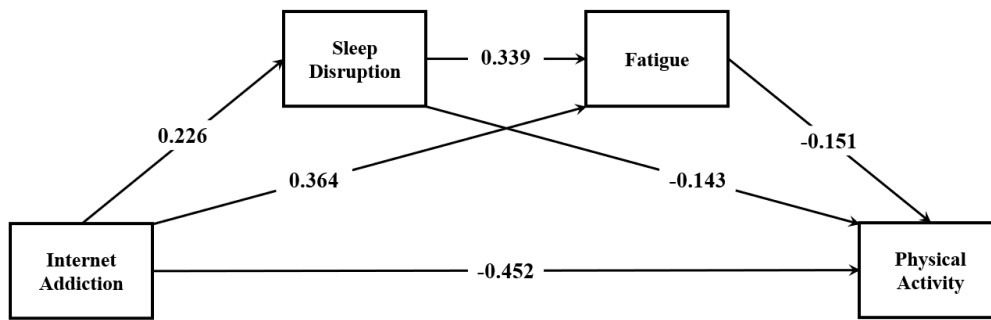


Figure 2. Diagram of the Chain Mediation Model.

Table 4. Path Analysis of Mediation Model.

Intermediate path	Effect Size	SE	Bootstrap 95% CI	Proportion of Mediating Effect
Total Effect	-0.149	0.048	-0.240, -0.057	
Direct Effect	-0.042	0.041	-0.123, -0.041	
Internet Addiction ⇒ Sleep Disruption ⇒ Physical Activity	-0.083	0.022	-0.134, -0.042	55.667%
Internet Addiction ⇒ Fatigue ⇒ Physical Activity	-0.020	0.011	-0.045, -0.004	12.667%
Internet Addiction ⇒ Sleep Disruption ⇒ Fatigue ⇒ Physical Activity	-0.008	0.004	-0.020, -0.002	6.000%
Total Indirect Effect	-0.112	0.028	-0.174, -0.062	74.333%

4. Discussion

The association between IA and the engagement in PA among youth is widely acknowledged; however, the underlying mechanisms that facilitate this relationship remain inadequately explored in existing literature. This research seeks to investigate the mediating effects of sleep disruption and fatigue, which may act as significant pathways linking IA to diminished PA in adolescents. The findings of this study reveal that IA is a significant negative predictor of PA among this demographic. Moreover, the mediation analysis indicates that IA is positively associated with sleep disruption, which subsequently exerts a detrimental effect on PA. Additionally, the study highlights that IA correlates with heightened fatigue, which also adversely affects adolescents' engagement in PA. Importantly, the results suggest that both sleep disruption and fatigue fully mediate the relationship between IA and PA. These outcomes align with previous research (23,25,28-30), reinforcing the idea that increased IA correlates with decreased PA, heightened sleep disturbances, and greater feelings of fatigue among adolescents. Ultimately, the study underscores the importance of considering sleep issues and fatigue as potential mechanisms influencing the relationship between IA and PA in this age group.

Regarding the mediating role of sleep disruption in the relationship between IA and reduced PA, it can be several explanations. One potential explanation for the relationship between problematic internet use and sleep disruption is grounded in the "time displacement theory" (31). This theory suggests that engaging in unstructured leisure activities online, which lack defined start and end times, can lead individuals to spend excessive amounts of time on the internet. Consequently, this extended usage may encroach upon time that could otherwise be allocated to essential activities, including sleep. Additionally, another contributing factor may be the impact of light emitted from devices used for internet access. Research indicates that screens with LED backlighting emit significant amounts of short-wavelength light, which has been shown to inhibit the secretion of melatonin

during evening hours (32). This suppression of melatonin can lead to a decrease in both objective and subjective feelings of sleepiness, further exacerbating sleep disturbances associated with excessive internet use.

In addition, the relationship between sleep disruption and subsequent reduced participation in PA is likely influenced by multiple interconnected pathways. As shown in this study, disrupted sleep is associated with fatigue. It has also been shown that sleep disruption is associational with various negative outcomes, including diminished cognitive function, reduced concentration, and an elevated risk of stress-related disorders, which can lead to social withdrawal and feelings of loneliness (33,34). Factors such as fatigue and tiredness can significantly reduce an individual's motivation to PA. Research consistently indicates that these feelings often arise from insufficient sleep, poor sleep quality, sleep-disordered breathing, and being awake during times when the body is naturally predisposed to rest (33,35). Furthermore, research indicates that sleep deprivation is linked to increased self-reported fatigue, diminished arousal, and impaired behavioral inhibition and attention. Additionally, individuals tend to exhibit higher smoking behavior after a night of inadequate sleep compared to a night of sufficient rest (31,36). Additionally, research strongly suggests that insufficient sleep is associated with increased caloric consumption and poor food choices, which can ultimately lead to weight gain (32,35). This relationship plays a significant role in linking poor sleep patterns to PA. Additionally, adequate sleep is essential for muscle recovery and peak physical performance, highlighting the critical role of sleep in sustaining an active lifestyle.

This study contributes to the theoretical understanding of the interplay between IA and PA in adolescents by elucidating the underlying mechanisms through sleep disruption and fatigue. By identifying a chain mediating pathway, our findings extend existing frameworks on behavioral addictions and adolescent health. Moreover, the results provide empirical support for integrative models that link digital behavior, sleep physiology, and energy regulation, offering a more nuanced perspective on

how modern lifestyle factors interact to influence adolescent well-being. This theoretical insight can guide future research in developing comprehensive models that account for the complex, multi-step pathways through which technology use affects health behaviors.

This study, while valuable, is not without its limitations. The cross-sectional design restricts the ability to draw causal inferences regarding the relationships among IA, sleep disruption, fatigue, and PA. Second, reliance on self-reported measures may introduce reporting bias, particularly in sensitive areas such as internet use and fatigue levels. Third, the sample may not be fully representative of all adolescents, limiting the generalizability of the findings across different cultural or socio-economic contexts. Finally, while sleep disruption and fatigue were examined as mediators, other potential psychological or environmental factors, such as stress, peer influence, or parental monitoring, were not considered and may also play important roles in shaping adolescents' PA.

4.1. Conclusion

The cross-sectional study conducted among adolescents uncovered a significant dose-response relationship, demonstrating that increased severity of IA correlates with a decline in PA. Additionally, the findings indicated that sleep disturbances and fatigue play a significant mediating role in this relationship, suggesting that adolescents facing IA may experience diminished PA partly due to the adverse effects of disrupted sleep and resulting fatigue. Therefore, it is imperative for researchers and public health policymakers to enhance their understanding of how IA and sleep patterns interact with PA across various age groups, as this insight is vital for developing effective intervention strategies that promote healthy sleep habits and adequate levels of physical activity.

Acknowledgments

The author is grateful to all participants who took part in this research.

Footnotes

Authors' Contribution: This study was carried out solely by the corresponding author.

Conflicts of Interest

Non to declare.

Data Availability: The data that support the findings of this study are openly available upon request from the corresponding author.

Ethical Approval: The author confirms that all steps and requirements of this study comply with ethical guidelines. Participants were informed about the characteristics of the study and gave written informed consent.

Funding Support

This study received no grant.

Informed Consent: Informed written consent was obtained from all participants

Supplementary information accompanies this paper at doi: 10.22034/pach.2025.549827.1071

ORCID iD

Rezvaneh Makki  <https://orcid.org/0009-0000-9757-9327>

References

- Firth J, Torous J, López-Gil JF, Linardon J, Milton A, Lambert J, Smith L, Jarić I, Fabian H, Vancampfort D, Onyeaka H, Schuch FB, Firth JA. From "online brains" to "online lives": understanding the individualized impacts of Internet use across psychological, cognitive and social dimensions. *World Psychiatry*. 2024;**23**(2):176-190. [PubMed ID: 38727074]. [PubMed Central ID: PMC1083903] <https://doi.org/10.1002/wps.21188>
- Ashraf MA, Khan MN, Chohan SR, Khan M, Rafique W, Farid MF, Khan AU. Social Media Improves Students' Academic Performance: Exploring the Role of Social Media Adoption in the Open Learning Environment among International Medical Students in China. *Healthcare (Basel)*. 2021;**9**(10):1272. [PubMed ID: 34682952]. [PubMed Central ID: PMC8535783] <https://doi.org/10.3390/healthcare9101272>
- Moreno MA, Binger K, Zhao Q, Eickhoff J, Minich M, Uhls YT. Digital Technology and Media Use by Adolescents: Latent Class Analysis. *JMIR Pediatr Parent*. 2022;**5**(2):e35540. [PubMed ID: 35507401]. [PubMed Central ID: PMC9118083] <https://doi.org/10.2196/35540>
- Meng SQ, Cheng JL, Li YY, Yang XQ, Zheng JW, Chang XW, Shi Y, Chen Y, Lu L, Sun Y, Bao YP, Shi J. Global prevalence of digital addiction in general population: A systematic review and meta-analysis. *Clin Psychol Rev*. 2022;**92**:102128. [PubMed ID: 35150965]. <https://doi.org/10.1016/j.cpr.2022.102128>
- Schimmenti A. Beyond Addiction: Rethinking Problematic Internet use from a Motivational Framework. *Clin Neuropsychiatry*. 2023;**20**(6):471-478. [PubMed ID: 38344462]. [PubMed Central ID: PMC10852406] <https://doi.org/10.36131/cnforitieditore20230601>
- Ding K, Shen Y, Liu Q, Li H. The Effects of Digital Addiction on Brain Function and Structure of Children and Adolescents: A Scoping Review. *Healthcare (Basel)*. 2023;**12**(1):15. [PubMed ID: 38200921]. [PubMed Central ID: PMC10779052] <https://doi.org/10.3390/healthcare12010015>
- Naslund JA, Bondre A, Torous J, Aschbrenner KA. Social Media and Mental Health: Benefits, Risks, and Opportunities for Research and Practice. *J Technol Behav Sci*. 2020;**5**(3):245-257. [PubMed ID: 3345185]. [PubMed Central ID: PMC7785056] <https://doi.org/10.1007/s41347-020-00134-x>
- Alavi SS, Maracy MR, Jannatifard F, Eslami M. The effect of psychiatric symptoms on the internet addiction disorder in Isfahan's University students. *J Res Med Sci*. 2011;**16**(6):793-800. [PubMed ID: 22091309]. [PubMed Central ID: PMC3214398]
- Zamboni L, Portoghese I, Congiu A, Carli S, Munari R, Federico A, Centoni F, Rizzini AL, Lugoboni F. Internet Addiction and Related Clinical Problems: A Study on Italian Young Adults. *Front Psychol*. 2020;**11**:571638. [PubMed ID: 33240160]. [PubMed Central ID: PMC7683388] <https://doi.org/10.3389/fpsyg.2020.571638>
- Pezzi M, Corsano P, Santoro G, Gori A, Gámez-Guadix M, Musetti A. Solitary Experience and Problematic Social Media Use Among Young Adults: A Systematic Review with Recommendations for Future Research. *Clin Neuropsychiatry*. 2024;**21**(4):284-298. [PubMed ID: 39309023]. [PubMed Central ID: PMC11411510] <https://doi.org/10.36131/cnforitieditore20240405>
- Klein P, Fairweather AK, Lawn S. Structural stigma and its impact on healthcare for borderline personality disorder: a scoping review. *Int J Ment Health Syst*. 2022;**16**(1):48. [PubMed ID: 36175958]. [PubMed Central ID: PMC9520817] <https://doi.org/10.1186/s13033-022-00558-3>
- Ghorbani S, Rezaeeshirazi R, Shakki M, Noohpisheh S, Farzanegi P. The role of BMI, physical activity and the use of electronic device in the status of trunk abnormalities in male adolescents. *J Gorgan Univ Med Sci*. 2020;**22**(3):129-136. <http://goums.ac.ir/journal/article-13676-en.html>
- Dana A, Ranjbari S, Chaharbaghi Z, Ghorbani S. Association between Physical Activity and Motor Proficiency among Primary School Children. *Int J School Health*. 2023;**10**(3):128-135. <https://doi.org/10.30476/intjsh.2023.98237.1295>
- Baniasadi T, Ranjbari S, Abedini A, Dana A, Ghorbani S. Investigation the Association of Internet Addiction with Mental Health and Physical Activity in Teenage Girls: The Mediating Role of Parental Attitude. *Women Health Bull*. 2022;**9**(4):243-250. <https://doi.org/10.30476/whb.2022.96915.1197>
- Chaharbaghi Z, Hosseini FB, Baniasadi T, Moradi L, Dana A. Impact of Physical Activity on Resilience among Teenage Girls during the COVID-19 Pandemic: a Mediation by Self-Esteem. *Women Health Bulletin*. 2022;**9**(2):80-85. <https://doi.org/10.30476/whb.2022.94451.1166>

16. Afrin S, Rahman NA, Tabassum TT, Abdullah F, Rahman MI, Simu SH, Kumar L, Noor K, Vishal F, Podder V. The Impact of Internet Addiction on Academic Performance Among Medical Students in Bangladesh: A Cross-Sectional Study and the Potential Role of Yoga. *Ann Neurosci*. 2024;09727531241235999. [PubMed ID: 39544661]. [PubMed Central ID: PMC11559936] <https://doi.org/10.1177/09727531241235999>
17. Öztekin GG. Associations between internet addiction and school engagement among Turkish college students: mediating role of psychological distress. *Front Psychol*. 2024;15:1367462. [PubMed ID: 38487659]. [PubMed Central ID: PMC10937731] <https://doi.org/10.3389/fpsyg.2024.1367462>
18. Devi KA, Singh SK. The hazards of excessive screen time: Impacts on physical health, mental health, and overall well-being. *J Educ Health Promot*. 2023;12:413. [PubMed ID: 38333167]. [PubMed Central ID: PMC10852174] https://doi.org/10.4103/jehp.jehp_447_23
19. Nochian MA, Mousavi S, Khosravi H, Basirinezhad MH, Mirhosseini S. Association between internet addiction and musculoskeletal disorders in Iranian medical sciences students. *BMC Musculoskelet Disord*. 2024;25(1):662. [PubMed ID: 39180017]. [PubMed Central ID: PMC11342478] <https://doi.org/10.1186/s12891-024-07780-9>
20. Kuss DJ. Online harms: Problematic technology use is a public health concern and requires a multistakeholder approach. *Addict Behav Rep*. 2025;21:100602. [PubMed ID: 40248689]. [PubMed Central ID: PMC12005312] <https://doi.org/10.1016/j.abrep.2025.100602>
21. Gür F, Gür GC. The Relationship Between Physical Activity and Problematic Internet Use in Turkish College Students: The Chain-Mediated Role of Self-Control and Distress. *Psychiatr Q*. 2025;96(3):641-663. [PubMed ID: 40180754]. [PubMed Central ID: PMC12460438] <https://doi.org/10.1007/s11126-025-10133-x>
22. Zhu J, Zhai Y, Meng X, Zhang Z, Yuan X. The relationship between physical activity and Internet addiction among Chinese adolescents: exploring latent profile analysis and multi-level mediating mechanisms. *Front Psychol*. 2025;16:1628586. doi: 10.3389/fpsyg.2025.1628586. Erratum in: *Front Psychol*. 2025;16:1680220. [PubMed ID: 40703722]. [PubMed Central ID: PMC12284799] <https://doi.org/10.3389/fpsyg.2025.1628586>
23. Zhang X, Nie J, Sun Z, Wang X, Xu K, Li F, Liu Z. Internet addiction and anxiety-depressive comorbidity among Chinese adolescents: the mitigating effects of physical activity in a large-scale cross-sectional study. *BMC Public Health*. 2025;25(1):2898. [PubMed ID: 40846929]. [PubMed Central ID: PMC12372398] <https://doi.org/10.1186/s12889-025-24137-6>
24. Sela Y, Bar-Or RL, Kor A, Lev-Ran S. The Internet addiction test: Psychometric properties, socio-demographic risk factors and addictive co-morbidities in a large adult sample. *Addict Behav*. 2021;122:107023. [PubMed ID: 34198053]. <https://doi.org/10.1016/j.addbeh.2021.107023>
25. Wang W, Wang J, Liu Y, Deng L. Exploring the relationship between physical activity and social media addiction among adolescents through a moderated mediation model. *Sci Rep*. 2025;15(1):22209. [PubMed ID: 40594419]. [PubMed Central ID: PMC12215991] <https://doi.org/10.1038/s41598-025-05173-z>
26. Khanbeiki A. The Effects of Mindfulness Training in the Physical Education on Intention to Physical Activity, Mental Health and Academic Performance among High-School Students. *Phys Act Child*. 2024;1(1):68-73. <https://doi.org/10.61186/PACH.2024.470015.1022>
27. Strober LB, Bruce JM, Arnett PA, Alschuler KN, DeLuca J, Chiaravalloti N, Lebkuecher A, Di Benedetto M, Cozart J, Thelen J, Guty E, Román CAF. Tired of not knowing what that fatigue score means? Normative data of the Modified Fatigue Impact Scale (MFIS). *Mult Scler Relat Disord*. 2020;46:102576. [PubMed ID: 33296974]. <https://doi.org/10.1016/j.msard.2020.102576>
28. Wang J, Xiao T, Liu Y, Guo Z, Yi Z. The relationship between physical activity and social network site addiction among adolescents: the chain mediating role of anxiety and ego-depletion. *BMC Psychol*. 2025;13(1):477. [PubMed ID: 40329384]. [PubMed Central ID: PMC12057064] <https://doi.org/10.1186/s40359-025-02785-y>
29. Sun Y, Wang Y, Yu H, Liu J, Feng X. The effect of physical activities on internet addiction in college students: the mediating effect of self-control. *Front Psychol*. 2025;16:1530740. [PubMed ID: 39973945]. [PubMed Central ID: PMC11835871] <https://doi.org/10.3389/fpsyg.2025.1530740>
30. Yin Z, Yang C, Liu T, Yu J, Yu X, Huang S, Zhang Y. The relationship between physical activity and sleep quality among college students: The chain-mediating effects of self-control and mobile phone addiction. *PLoS One*. 2024;19(12):e0315930. [PubMed ID: 39700194]. [PubMed Central ID: PMC11658481] <https://doi.org/10.1371/journal.pone.0315930>
31. Larsson SC, Hällström E, Michaëlsen K, Titova OE. Poor sleep is associated with lower physical activity in a population-based cohort of middle-aged and older adults. *Sci Rep*. 2025;15(1):26012. [PubMed ID: 40676117]. [PubMed Central ID: PMC12271448] <https://doi.org/10.1038/s41598-025-10991-2>
32. Silvani MI, Werder R, Perret C. The influence of blue light on sleep, performance and wellbeing in young adults: A systematic review. *Front Physiol*. 2022;13:943108. [PubMed ID: 36051910]. [PubMed Central ID: PMC9424753] <https://doi.org/10.3389/fphys.2022.943108>
33. Harris AL, Carmona NE, Moss TG, Carney CE. Testing the contiguity of the sleep and fatigue relationship: a daily diary study. *Sleep*. 2021;44(5):zsaa252. [PubMed ID: 33245330]. <https://doi.org/10.1093/sleep/zsaa252>
34. Fullagar HH, Skorski S, Duffield R, Hammes D, Coutts AJ, Meyer T. Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. *Sports Med*. 2015;45(2):161-86. [PubMed ID: 25315456]. <https://doi.org/10.1007/s40279-014-0260-0>
35. Ortega FB, Chillón P, Ruiz JR, Delgado M, Albers U, Alvarez-Granda JL, Marcos A, Moreno LA, Castillo MJ. Sleep patterns in Spanish adolescents: associations with TV watching and leisure-time physical activity. *Eur J Appl Physiol*. 2010;110(3):563-73. [PubMed ID: 20556419]. <https://doi.org/10.1007/s00421-010-1536-1>
36. Holfeld B, Ruthig JC. A longitudinal examination of sleep quality and physical activity in older adults. *J Appl Gerontol*. 2014;33(7):791-807. [PubMed ID: 25231754]. <https://doi.org/10.1177/0733464812455097>