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ORIGINAL ARTICLE

Relationships between internet addiction, quality of life and sleep problems: a structural equation modeling analysis

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KEYWORDS
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Abstract
Objective: To assess the relationship between internet addiction, quality of life, and sleep problems among adolescents.
Method: This research was conducted with a representative sample of 875 adolescents. This cross-sectional study used the Internet Addiction Test, Pediatric Quality of Life Inventory™ version 4.0, Pediatric Daytime Sleepiness Scale, and sleep duration. Sociodemographic factors were also analyzed. Structural equation modeling was used to investigate relationships between variables.
Results: After adjusting the model for covariances between the latent variables of daytime sleepiness and correlations between the physical and emotional domains of quality of life, the authors obtained satisfactory fit indices (RMSEA = 0.031, CFI = 0.926, TLI = 0.909, SRMR = 0.058). Internet addiction was positively associated with daytime sleepiness (rho = 0.549, $p < 0.001$) and negatively associated with quality of life (rho = −0.173, $p < 0.001$). By contrast, sleep duration was negatively associated with daytime sleepiness (rho = −0.089, $p = 0.007$), positively associated with quality of life (rho = 0.105, $p = 0.014$), and dependent on school shift (rho = 0.453, $p < 0.001$).
Conclusions: Adolescents with higher levels of internet addiction had lower perceptions of quality of life and higher daytime sleepiness. Moreover, sleep duration had a positive correlation with quality of life. Given its detrimental effects on quality of life and daytime sleepiness, parents should better supervise internet use in adolescents.

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Introduction

Associated with the search for information, the Internet has become a major topic of research seeking to discuss the problematic use of technologies.[1] Studies about interaction with technologies have been carried out to investigate the disorders caused by inadequate use of different media, supported by the fact that a significant portion of the global population shows signs of technological dependence.[2]

Sampasa-Kanyinga et al. (2018)[3] identified that 86.3 % of Canadian adolescents use social media platforms daily, 42.9 % of whom remain connected for more than 2 h a day. A longitudinal research carried out in 2008 and 2009 in the Netherlands demonstrated that 3 % of the sampled adolescents (aged 13 to 16 years) displayed symptoms of addiction.[4] These findings underscore the importance of evaluating factors associated with an individual's search for technological environments. Such investigations may contribute to the resolution of physical and psychological health problems. According to previous reports, exacerbated interaction with technologies can cause disorders, such as obesity, depression, attention-deficit/hyperactivity disorder (ADHD), and obsessive-compulsive disorder (OCD), as well as problems with drugs and sleep.[3]

Prolonged use of technologies before sleep is a current, severe problem permeating all age groups; however, it is in adolescence that this behavior is more worrisome, as it may lead to several sleep-related problems, including sleep deprivation.[3,5] According to the United States National Sleep Foundation, the recommended amount of sleep for adolescents is 8 to 10 h a day. Adolescents who have excessive daily use of technologies, however, have dramatically fewer hours of sleep.[6]

It is important to understand the causes of sleep-related problems in adolescents, and how they reflect on quality of life. It is worth noting that quality of life is an eminently human notion, which has been approximated to the degree of satisfaction in familiar, emotional, social, and environmental lives and to the existential aesthetic itself.[7] However, such a perception depends on the subjective interpretation of each individual, varying according to their sensitivity, culture, socioeconomic condition, plans, and frustrations.[8] Thus, the possibility of evaluation and operationalization depends on the approach used and indicators of scientific and political interests for each area of research[9] and age group.

Adolescence is a period during which individuals establish behaviors that will extend into adulthood, involving physical, cognitive, emotional, and social changes.[10] Adolescents are subject to behaviors that pose health risks, including high exposure to screen-based media (television and Internet), low sleep duration, and sedentary behavior.[5] In view of the above, it is hypothesized that excessive internet use is associated with negative effects on sleep duration and daytime sleepiness, consequently impairing quality of life, given that these variables are interrelated. Studies are necessary to investigate the factors that can affect adolescent health, especially from the perspective of understanding a highly frequent and accessible behavior, such as internet use. This study aimed to assess the relationship between internet addiction, quality of life, and sleep problems among adolescents.

Methods

This is a descriptive study with an observational, epidemiological, and cross-sectional design. All experimental procedures were performed in accordance with ethical principles, approved by the Ethics Committee no. 081280/2018. The study population comprised 3762 adolescents enrolled in the final grades of elementary education in 12 public schools. The sample size was calculated as follows: confidence level of 1.96 (95 % confidence interval), tolerable error of 5 percentage points, prevalence of 50 % (unknown outcome), design effect of 1.5 per sample cluster, and loss or dropout rate of 15 %. The minimum sample size was estimated at 601 individuals, and the final sample included 875 students.[11]

Sample selection consisted of a simple random sampling of state schools. Subsequently, the schools were contacted and informed about the research project, methodological procedures, and steps in data collection. Adolescents in the final years of elementary education signed an informed consent form after receiving written informed consent from their parents or guardians. Only students present in the classroom at the time of data collection were included in the survey. Participation was voluntary, and all students attending the selected classes were invited to participate.

Variables related to health components, quality of life, school environment, internet addiction, sleep problems, and socioeconomic profile were investigated. Socioeconomic variables included sex (male/female), age (9—18 years), social class (high, middle, low), and school shift (morning/afternoon).

The socioeconomic profile of adolescents was assessed using the Brazilian Criteria of Economic Classification (2018), as recommended by the Brazilian Association of Research Companies.[12] This instrument estimates the purchasing power of urban individuals and families; higher scores indicate higher socioeconomic levels. The sum of item scores was used to classify students into economic levels (A, B1, B2, C1, C2, D, and E) and subsequently into socioeconomic classes (high, A and B1; middle, B2; and low, C1, C2, D, and E).

Internet addiction was measured using the Internet Addiction Test (IAT), which was created[13] and validated for assessing different degrees of Internet dependence. The instrument was translated and adapted to Portuguese.[14] The questionnaire consists of 20 objective questions with five response categories (0, does not apply; 1, rarely; 2, occasionally; 3, frequently; 4, often; and 5, always). Total scores range from 20 to 100, with higher scores indicating more severe levels of addiction.

Students' perceptions of quality of life were assessed using the Pediatric Quality of Life Inventory™ version 4.0, developed and validated in English by Varni et al. (2003)[15] and validated in Brazilian Portuguese by Klatchoian et al. (2008).[16] There are 23 items assessing physical (8 items), emotional (5 items), social (5 items), and school (5 items) domains. Values are then operationalized and transformed to an inverse linear scale ranging from 0 to 100, where the highest score represents the best perception of quality of life.

Sleep duration was used as an indicator of sleep problems and calculated from the difference between sleep and wake times on school days and non-school days. This assessment method was developed by Louzada and Menna-Barreto (2004).[17]

Table 1 Descriptive characteristics of the sample.

Variable	Total n (%)[a]	Sex		p-value[b]
		Male n (%)[a]	Female n (%)[a]	
Age, years	13.2 (1.7)	13.4 (1.7)	12.9 (1.6)	< 0.001
School shift				0.139
Morning	455 (52)	221 (49)	234 (54)	
Afternoon	420 (48)	225 (50)	195 (45)	
School grade				0.119
Fifth	141 (16)	62 (13)	79 (18)	
Sixth	131 (15)	75 (16)	56 (13)	
Seventh	148 (16)	73 (16)	75 (17)	
Eighth	235 (26)	114 (25)	121 (28)	
Ninth	220 (25)	122 (27)	98 (22)	
Social class				0.691
High	112 (18)	58 (13)	54 (12)	
Middle	228 (37)	117 (26)	111 (25)	
Low	275 (44)	132 (29)	143 (33)	
Internet addiction score	45.5 (15.9)	45.4 (14.7)	45.7 (17.0)	0.719
Daytime sleepiness score	15.4 (5.5)	14.6 (5.7)	16.2 (5.2)	< 0.001
Sleep duration, h	8.7 (1.9)	8.7 (1.9)	8.7 (1.9)	0.573
Quality of life scores				
Physical domain	80.3 (15.4)	84.0 (13.6)	76.5 (16.3)	< 0.001
Emotional domain	61.4 (22.5)	57.5 (20.1)	55.0 (23.1)	< 0.001
Social domain	83.8 (17.1)	85.3 (16.4)	82.2 (17.7)	0.010
School domain	70.3 (18.2)	71.6 (18.0)	69.0 (18.4)	0.043
Total quality of life	74.7 (13.7)	78.0 (11.9)	71.4 (14.7)	< 0.001

[a] Numerical variables are presented as mean ± standard deviation and categorical variables as absolute (*n*) and relative (%) frequencies.
[b] Categorical variables were compared by the chi-square test and dichotomous variables by the Mann–Whitney *U test*.

Excessive daytime sleepiness was identified using the Pediatric Daytime Sleepiness Scale (PDSS) created by Drake et al. (2003).[18] The original English version was translated and validated in Brazil by Felden et al. (2016).[5] The PDSS questionnaire consists of eight multiple-choice items, each item is rated on a 5-point Likert scale; the third item is scored in reverse. Total scores range from 32 (highest daytime sleepiness level) to 0 (lowest daytime sleepiness level).

Statistical analysis

Data analysis was performed using the following software: Statistical Package for the Social Sciences (SPSS) version 20.0 and Stata/MP version 13.0 (StataCorp, Lakeway Dr, College Station, TX, USA). The Kolmogorov–Smirnov test showed that the data were not normally distributed. Descriptive statistics are presented as mean and standard deviation or absolute and relative frequencies. For inferential analyses, differences between proportions were identified by the chi-square test and correlations were assessed using Spearman's correlation coefficient. Finally, data were subjected to structural equation modeling.

A weighted least squares model was used because normality assumptions were not met. Weighted least squares methods are also appropriate when categorical variables are included in the model.[19] Cut-off points for model suitability followed the global model fit criteria proposed by Hu and Bentler (1999):[20] root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR) of 0 to 0.8. (12,34) For the comparative fit index (CFI) and the Tucker–Lewis index (TLI), values greater than 0.90 were considered acceptable.[21] Finally, modification indices were estimated to identify alternative models that could provide a better fit to the data. The significance level adopted for all statistical tests was 5 %.

Results

The study sample comprised 875 adolescents with a mean age of 13.2 (1.7) years. Most students attended school in the morning shift (52 %), had low socioeconomic levels (44 %), and were male (51 %). In assessing differences between sexes, the authors found that boys were older ($p < 0.001$) and had a more positive perception of total quality of life ($p < 0.001$) and quality of life domains ($p < 0.05$). Girls had a higher mean score for daytime sleepiness ($p < 0.001$) (Table 1).

Correlations between internet addiction and quality of life domains were significant and negative ($p < 0.001$). The results showed that the higher the IAT score, the greater the negative perception of total quality of life (rho = −0.358, $p < 0.001$) and physical (rho = −0.372, $p < 0.001$), emotional (rho = −0.273, $p < 0.001$), social (rho = −0.289, $p < 0.001$), and school (rho = −0.250, $p < 0.001$) domains (Table 2).

Negative and positive correlations were observed between internet addiction and sleep duration (rho = −0.212, $p < 0.001$) and daytime sleepiness (rho = 0.372, $p < 0.001$), respectively (Table 3).

Table 2 Correlations between internet addiction and total quality of life and its domains.

Variable	Internet addiction	
	rho[a]	p-value
Total quality of life score	−0.372	< 0.001
Physical domain score	−0.273	< 0.001
Emotional domain score	−0.289	< 0.001
Social domain score	−0.250	< 0.001
School domain score	−0.358	< 0.001

[a] Spearman rho correlation coefficient.

Table 3 Correlations between internet addiction and sleep quality.

Variable	Internet addiction	
	rho[a]	p-value
Sleep duration	−0.212	< 0.001
Daytime sleepiness	0.372	< 0.001

[a] Spearman rho correlation coefficient.

Structural equation modeling was used for the final analysis of this study to investigate the relationships between internet addiction, daytime sleepiness, sleep duration, school shift, and quality of life. According to the initial hypothesis, all variables were included in the model. In addition to the relationships depicted in Figure 1, the authors considered the direct relationship between internet addiction and sleep duration and between daytime sleepiness and quality of life; however, these relationships were found to be non-significant (p = 0.302 and p = 0.183, respectively) and were thus excluded from the model.

After adjusting the model for covariances between latent variables in PDSS, which measures the daytime sleepiness of adolescents, and for correlations between physical and emotional quality of life, the authors obtained satisfactory fit indices for the global model (RMSEA = 0.031, CFI = 0.926, TLI = 0.909, SRMR = 0.058). The results showed that internet addiction was positively associated with daytime sleepiness (rho = 0.549, $p < 0.001$) and negatively associated with quality of life (rho = −0.173, $p < 0.001$), indicating that the higher the internet addiction, the higher the daytime sleepiness and the lower the quality of life of adolescents (Figure 1).

Sleep duration, on the other hand, was negatively associated with daytime sleepiness (rho = −0.089, p = 0.007), positively associated with quality of life (rho = 0.105, p = 0.014), and dependent on school shift (rho = 0.453, $p < 0.001$). Finally, longer sleep duration was associated with a better perception of quality of life (Figure 1).

Discussion

The present study aimed to investigate the relationship between internet addiction, quality of life, and sleep problems in adolescents. It was hypothesized that the greater the internet addiction, the shorter the sleep duration and, consequently, the worse the quality of life, and that these variables are associated. The findings revealed that there is a correlation between excessive internet use and negative perception of quality of life in all its domains. Furthermore, it was demonstrated that the greater the internet addiction, the shorter the sleep duration and the greater the daytime sleepiness. However, structural equation modeling showed that the direct relationship between internet addiction and sleep duration is not significant; internet addiction was maintained in the model because it was significantly associated with daytime sleepiness, quality of life, and school shift.

It should be noted that this study found an average IAT score of 45 (Table 1), classified as excessive internet use.[13] According to a more up-to-date study on cut-off points, this score could be classified as mild internet dependence.[22] Exacerbated use can be classified as addiction to activities associated with the Internet, such as online games, which was included in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5, 2014).[23] However, this classification does not involve the total use of the Internet, being limited only to games.

With the aim of filling this knowledge gap, the present study investigated internet use and its relationships with other factors. No significant difference between the sexes was identified. Sex differences were observed, however, in previous studies analyzing the relationship with computer games: young males are more likely to overuse.[1,2] The results of the current study may be attributed to the fact that internet use among girls was compensated by the use of social networks, chatting with other people by instant messaging or e-mail, and reading news on websites of newspapers, magazines, and other forms of media, equating to the level of internet use of boys.

Internet addiction was found to be negatively correlated with quality of life, in agreement with previous studies. Batista (2011)[24] identified a weak negative relationship between internet addiction and quality of life dimension among adolescents. However, in a correlational analysis between IAT and the quality of life domain, IAT had moderate significant correlations with all domains; the emotional domain exhibited the strongest correlation with IAT. The authors suggest that the perception that individuals have about the negative consequences of excessive internet use depends on how they link such effects to their feelings, self-esteem, body image, thinking, and learning; these facets are also associated with emotional and social factors.

Another unhealthy behavior identified in the present sample was daytime sleepiness. Girls had higher scores than boys, showing that they had a perception of greater daytime sleepiness. In line with the present findings, Matos et al. (2019),[25] in evaluating 3869 adolescents, found that girls had a higher risk for sleep-related problems, such as low sleep quality and short sleep duration. The authors attributed this result to the pubertal state occurring earlier in girls than in boys and to the various hormonal changes that may modify sleep patterns.[25] According to Liu et al. (2017),[26] gender differences in the risk of insomnia are common and seem to be associated with early menarche and the physical and endocrinological changes that occur rapidly thereafter.

A study conducted by Tsou and Chang (2019)[27] in Taiwan demonstrated that sleep deprivation was related to internet

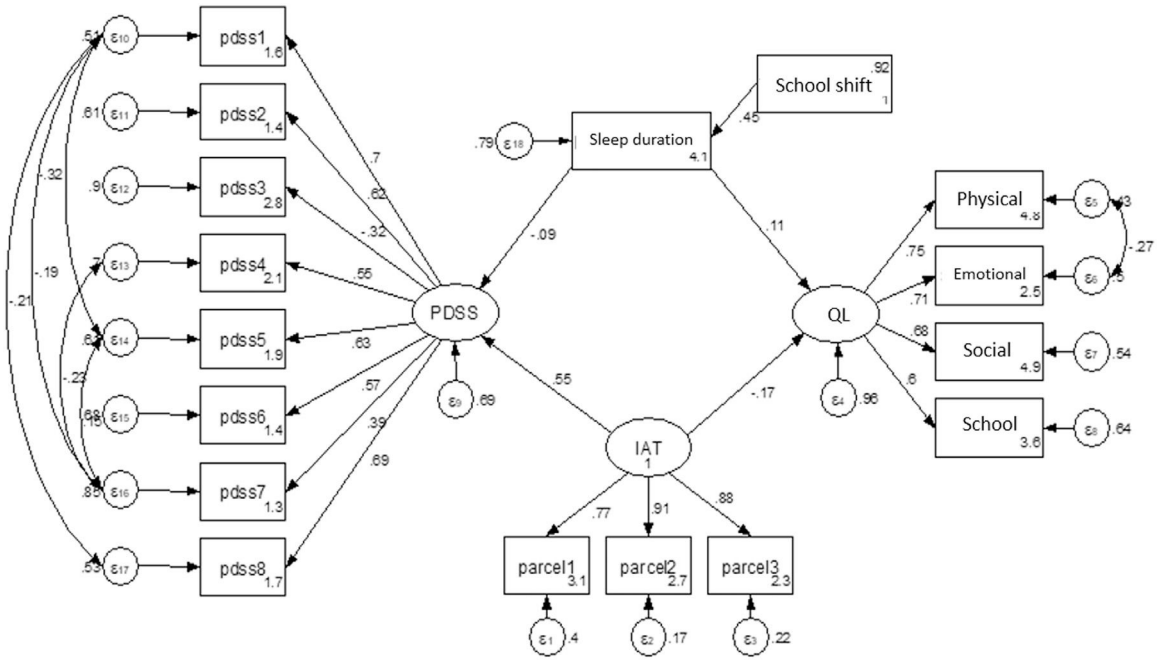

Figure 1 Structural equation modeling of associations between Internet Addiction Test (IAT) scores, Pediatric Daytime Sleepiness Scale (PDSS) scores, sleep duration, school shift, and quality of life (QL) scores. IAT, higher scores indicate higher internet addiction; PDSS, higher scores indicate higher daytime sleepiness; QL, higher scores indicate higher quality of life.

use time and could be predictive of depression in young individuals. A previous study[28] showed that sleep-related problems were strongly associated with smartphone use: excessive internet use led to a reduction in sleep duration, to the point that the average sleep duration of the sample was lower than the recommended for adolescents. This behavior occurs because most adolescents use the Internet in the afternoon and evening, during the period opposite their school shift. Thus, sleep duration is affected by early morning social obligations and the time spent on screen-based activities at night, leading to a delay in bedtime.[28] Such a correlation was identified in the present study. However, structural equation modeling revealed that the relationship between internet addiction and sleep duration was not significant. More studies are needed on this association for a better understanding of the implications of internet addiction on adolescent sleep.

Sleep duration directly influences daytime sleepiness in adolescents. The phenomenon may also be explained by maturational factors, which differ between individuals, causing changes in sleep. Such changes may lead to slower absorption of melatonin during dawn and slower release during the night, also known as process S, which represents the biological accumulation of melatonin throughout the day. The longer the time awake during the day, the greater the melatonin accumulation and the longer the sleep duration; these relationships, however, are not normally expressed in adolescents.[29] Ferrari Junior et al. (2018)[29], in studying 773 adolescents aged 14 to 19 years, identified that adolescents' perception of the need for more sleep was the best predictor of daytime sleepiness compared with other related variables: 73 % of the sample claimed to need more hours of sleep, suggesting that this is a common condition during this life stage.

The results partially confirm the hypothesis of this study. Structural equation modeling revealed a dynamic relationship in which internet addiction was positively associated with daytime sleepiness and negatively associated with quality of life, whereas sleep duration, conditioned by school shift, was negatively associated with daytime sleepiness and positively with quality of life. It can be assumed that these relationships are relevant to the adolescent stage, characterized by excess exposure to the Internet. Such exposure is explained by the increase in access to the Internet over the last decade and the growing importance of the Internet as a means to meet school demands and leisure needs.[30] Intensified internet use during adolescence runs in parallel with maturational changes that favor the delay of sleep. As a result of these deleterious circumstances, there is a decrease in sleep duration, and, depending on the school shift, an increase in daytime sleepiness.[30] In line with these findings, a previous study identified that morning and night school shifts do not fit well into adolescents' biological clock. Overall, the set of conditions identified here can impair the general health and quality of life of adolescents.

Some of the strengths of this study were the representative sample of adolescents and the robust statistical method used (structural equation modeling), which allowed for the assessment of the interaction of several variables. One of the weaknesses of the study was the transversality of data, precluding the identification of cause-and-effect relationships. In addition, the fact that the selection of disciplines used only students who were in the classroom may generate bias. For this reason, the sampling considered a design error of 1.5. Although suggested that future studies use a random sample of adolescents. Other variables could have been associated with the model, such as physical activity and sedentary behavior, which would have allowed more accurate

and targeted explanations. Given this, future studies are needed on internet addiction and its relation to physical and physiological factors to fill the current knowledge gap.

Conclusions

This study identified relationships between internet addiction, quality of life, and sleep problems in adolescents. Individuals with higher levels of internet addiction had lower perceptions of quality of life and higher daytime sleepiness. Sleep duration depended on school shift and had a positive correlation with quality of life.

These results indicate that internet use in adolescents should be better supervised by parents, given the evidence of detrimental effects on quality of life and daytime sleepiness. Furthermore, regarding morning social obligations, adolescents should be informed about the importance of getting sufficient sleep to avoid negative impacts on quality of life, such as daytime sleepiness.

Conflicts of interest

The authors declare no conflicts of interest.

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