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Examining the interplay between physical activity, problematic internet use and the negative emotional state of depression, anxiety and stress: insights from a moderated mediation path model in university students

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Abstract

Background The aim of this study was to investigate the relationship between Problematic Internet Use (PIU), emotional states of stress, anxiety and depression, and the practice of physical activity among Tunisian students.

Methods Cross-sectional data were collected from 976 university students aged 20.76 ± 1.63 years (46.8% female). They filled out an online survey comprised of a socio-demographic questionnaire, the depression, anxiety and stress scale– 21 items (DASS-21), the international physical activity questionnaire (IPAQ) and the compulsive internet use scale (CIUS). Students were divided, based on their economic levels, into three groups: low ($n = 256$, 26.23%), medium ($n = 523$, 53.59%) and high ($n = 197$, 20.18%).

Results Mediation analysis: Indirect effects of IPAQ and gender on DASS-21 were highlighted: β= -0.18 ($p < 0.01$) and β= -0.04, $P < 0.01$) respectively. In addition, a significant and negative effect of IPAQ on CIUS was demonstrated (β = -0.45, $P < 0.01$). In addition, the effect of CIUS on DASS-21 was significant (β = 0.39, $P < 0.01$). Also, the effect of gender on CIUS was significant (β=-0.10, $P < 0.01$) However, its effect on DASS-21 was not significant (β = 0.05, $p = 0.078$). The total effect of IPAQ on DASS21 was significant (β= -0.52, $p < 0.01$) but the effect of Gender on DASS-21 was not significant (β = 0.01, $p = 0.817$). Moderation analysis: the results showed a significant moderation effect of the interaction between IPAQ and Gender on CIUS (β = 0.07, $p < 0.01$). However, it was not significant between Gender and CIUS on DASS-21 (β = 0.09, $p = 0.390$) and between IPAQ and Gender on DASS21 (β = 0.01, $p = 0.736$) Also, the interaction between IPAQ and CIUS did not have a significant moderation effect on DASS-21 (β = 0.15, $p = 0.115$).

Conclusions Findings suggest that relationships between PIU and negative emotional state of depression, anxiety and stress are mediated via physical exercise. These results underscore the importance of the physical activity factor in the studies analyzing longitudinal effects of PIU on mental health outcomes.

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Keywords Problematic internet use, Physical activity, Moderation, Mediation, University student, Mental health

Introduction

Due to its proven usefulness in the field of education, entertainment and especially the transmission of information, the use of the Internet has become a reflection of the degree of societal progress [1]. The Internet allows millions of Internet users to access an almost unlimited source of information. It contributes to the development of collaboration with other users, the democratization of knowledge and even the ability to work remotely. Given the sanitary conditions caused by the COVID-19 pandemic, the growth of internet use, which was already rapid before, has seen a clear acceleration in recent years and has therefore become a customary habit [2–4]. According to a recent study, Problematic Internet Use (PIU) affects 7.02% of the world's population, with teenagers appearing to be particularly vulnerable [5].

Additionally, there are gender disparities in selected application categories which emphasize the need to explore the role of habits in understanding Problematic Internet Use (PIU). Notably, two distinct profiles have emerged: one characterized by the problematic use of video games, primarily among boys, and the other by the problematic use of social media, predominantly among girls [6]. Understanding how habits contribute to PIU is essential. Habits, defined as the actions that bring individuals happiness but disrupt their daily lives, have been identified as significant contributors to PIU [7]. Authors argue that habits leading to cognitive, social, and psychological distress can exacerbate PIU, transforming moderate internet use from a customary habit into a problematic behavior [7–9]. This transformation diminishes the educational and recreational aspects of internet use, leading to interference with daily life and potential addiction [1, 10]. Therefore, investigating the role of habits in PIU is crucial for developing targeted interventions and addressing the complexities of internet addiction among different demographic groups.

All uncontrollable behaviors related to the Internet, video games, excessive use of social media, passive search for information while ignoring other daily activities, can be included in PIU [1, 7, 8]. PIU is defined as "use of the Internet that creates psychological, social, school and/or work difficulties in a person's life" [9]. In a recent meta-analysis that included 40 studies, PIU was associated with significant impairment in inhibitory control, stop cue task, go/no-go task, decision-making, and working memory [10, 11].

Moreover, problematic internet use correlates with a higher prevalence of mental health problems among adolescents, including depression, anxiety, and social isolation [12]. Even though PIU has become quite a serious mental health problem, it has not yet been classified as a disorder in the Diagnostic and Statistical Manual of Mental Disorders, but it has been found to be a condition that requires further clinical investigation [13]. A recent study found that video game stimuli activate the brain in the same way induced by drug cues [14]. These authors showed that excessive cue exposure can affect sensory processing ability and self-reflection.

Other studies have shown that Internet addiction gives rise to the withdrawal syndrome which has negative repercussions on the family environment [15]. PIU leads to an increase in individualism, a decrease in sociability and enculturation [16].

According to neuropsychological studies, several symptoms of Internet addiction are linked to executive functions, including inhibition, working memory, and cognitive flexibility [17–20]. Recent research has also revealed that people with PIU may have problems with attention, motor inhibition, decision-making [10]and depression [21, 22].

Several studies have shown that there is a strong link between gender and PIU [21, 23–25]. The majority of available data has shown that generally men have significantly higher internet addiction rates than women [26–29]. Men may be more inclined to explore the unknown, which may lead them to be more attracted to substances that indicate addiction, such as pornography, online games, and cybersex [30, 31]. However, other study presented results that showed no discernible gender difference [32].

Anxiety, stress, and depression are prevalent mental health challenges among university students, significantly impacting their well-being and academic performance. According to recent studies, a substantial proportion of university students experience symptoms of anxiety, stress, or depression within a given timeframe. For instance, according to a study conducted by Kavvadas et al. [33], the prevalence of stress, anxiety, and depression among university students reveals concerning levels of mental health challenges. The research indicates that 21.3% of participants reported severely increased levels of stress, while 64.0% reported normal to mild levels of stress. Similarly, concerning proportions were observed for anxiety, with 23.3% of participants experiencing severely increased levels, juxtaposed with 66.5% reporting normal to mild anxiety levels. Additionally, the study found that 25.1% of participants exhibited severely increased levels of depression, while 57.2% reported normal to mild depressive symptoms.

The impact of anxiety, stress, and depression on students extends beyond their academic performance,

affecting their social relationships, overall quality of life, and future prospects. Moreover, the transition to university life, academic pressure, financial concerns, and social isolation can exacerbate these mental health challenges among students [34].

In response to these issues, there is growing recognition of the potential benefits of physical exercise for promoting mental health and well-being among university students. Numerous studies have demonstrated that regular physical exercise can have positive effects on mood regulation, stress reduction, anxiety management, and the alleviation of depressive symptoms [35–37].

The mechanisms underlying the beneficial effects of physical exercise on mental health are multifaceted. It stimulates the release of endorphins, neurotransmitters, and other neurochemicals that contribute to improved mood and stress resilience [38, 39]. Moreover, exercise promotes neuroplasticity in the brain, enhancing cognitive function and emotional regulation [40].

University students frequently suffer from social anxiety and academic pressure, which may increase their willingness to abuse the Internet as a momentary stress relief [41]. They use the internet excessively due to flexible hours and easy access. According to previous studies, between 8.6 and 40% of university students suffer from Internet addiction [41, 42]. A research on Brazilian university students revealed that 7.3% of them suffer from Internet addiction [43].

In addition, previous studies have found associations between PIU and mental health parameters such as stress, anxiety and depression in students [44–47]. For example, the study found that high Internet use was associated with high depression scores and high perceived stress scores [48].

University students frequently struggle with a lack of physical exercise due to their tendency to lead sedentary lifestyles as a result of spending too much time on their cell phones and social media [49].

The excessive and compulsive of the Internet use has a negative influence on individual mental health [16, 50–55]. Moreover, a previous study conducted on Korean adolescents indicated a negative association between level of physical activity and risk of PIU via the mediation of sleep satisfaction and stress [54]. The temporal allocation of time reserved for Internet use in spite of that allocated to physical activity led to a negative association between engagement in physical exercise and problematic Internet use [49]. This association stems from the fact that individuals with PIU tendencies have a disposition to reserve significant time for internet use, which substitutes for opportunities to engage in physical activity [56]. However, physical activity may have an inhibiting effect on problematic Internet use through its positive influence on negative emotional state.

Despite the large number of studies that have focused on the PIU, physical activity as well as on negative emotional state, to our knowledge, no study has addressed the association between these three concepts and specifically in the Arab world. Specially, Tunisia has one of the highest mobile phone subscriber rates in Africa with more than 15.6 million mobile lines in use [57] and PIU may affect users. In addition, recent studies in Tunisia have revealed that a considerable number of university students who use the Internet are vulnerable in terms of mental health [58].

The present study may shed light on interventions aimed at alleviating PIU and negative emotional state, ultimately improving mental health.

Accordingly, the aim of this study is to examine the links between PIU, negative emotional state (stress, anxiety and depression), gender, and the practice of physical activity among Tunisian students. We hypothesized that PIU would be influenced by gender and that there would be a positive correlation between negative emotional state and PIU. Also, the relationship between PIU and negative emotional state measured on the DASS21 are mediated and moderated via physical activity.

Materials and methods

Data collection and procedure

From November 10 to December 12, 2022, cross-sectional data were gathered using a survey created online using the Google Forms tool. An english language version of the survey is available as a supplementary file.

The questionnaire includes two sections: the first includes the socio-demographic questionnaire while the second includes the CIUS, the DASS21 and the subjective measurement of physical activity IPAQ.

The socio-demographic questionnaire includes age, gender, economic level (low/medium/high), place of residence of students (university hostel, residence with family, rental house with friends). In addition, the students were questioned by the following question on the use of the Internet: "What mainly use the Internet? ". The responses were coded into three responses (to play, to access social networks, or other purpose).

For the purpose of disseminating the questionnaire and including the most target individuals possible, we employed a snowball sampling technique to gather data from Tunisian students who were active on Facebook. Initially, Facebook student groups were used to deliver invitations to complete an informed consent form through individual Google Gmail accounts.

The responders then requested that their friends participate in the poll. To be able to manage various replies, this process enables the creation of a specialized vote box. We employed this environment, which is based on the Cloud Computing technology used by the Google

application and enables for a single answer per user. To protect user confidentiality, privacy, and security, the usage of this method necessitates having a Google email account, and it forbids access to Internet Protocol (IP) addresses of users. There was no collection of personal data in the answer form (e.g., names, home addresses, email addresses, and phone numbers). The study complies with the CHERRIES (Recommended Standards for Conducting and Reporting Internet Surveys) guidelines.

Any student Facebook user who is at least 18 years old, resides in Tunisia, and speaks Arabic as their first language meets the inclusion requirements. To preserve the same social and cultural setting at the time of the survey, however, participants who do not live in the nation are not included in the research.The exclusion criteria involve subjects who have mental disorders (extremely severe scores) according to DASS21.

To obtain an adequate number of participants, we used an online calculator [59] used in previous studies referring to the number of students in Tunisia. Recent statistics reveal that the number of students in Tunisian universities is nearly 300,000 students [60]. A minimum number of 664 students is required (66% response rate, 5% margin of error, and 50% proportion with a 99% CI). This research has been approved by the Research Ethics Committee of the Institute of Sport and Physical Education at Kef, Jendouba University in Tunisia's.

Instruments

The DASS-21 questionnaire

To assess stress, anxiety, and depression, an Arabic version of the DASS-21 was used. This version of the DASS-21 demonstrated a good reliably and validity across studies [61–63].

The DASS-21 is a self-assessment questionnaire that contains 21 items divided into three subscales. Each subscale consists 7 items that assess symptoms of depression (items 3, 5, 10, 13, 16, 17, 21), anxiety (items 2, 4, 7, 9, 15, 19, 20) and stress (items 1, 6, 8, 11, 12, 14, 18). Participants rate the severity of each symptom over the course of the past week on a four-point scale ranging from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time). The total score for each subscale ranges from 0 to 21, with higher scores indicating higher levels of depression, anxiety, and stress [64, 65]. The DASS-21's psychometric properties were adequate, as proven by its good internal consistency reliability (Cronbach's alpha ranged around 0.74 to 0.93) in studies that included both clinical and non-clinical populations [66], Additional information on the scoring of the DASS 21 is illustrated in additional file 1.

The arabic short version of the international physical activity questionnaire

To assess physical activity, the short Arabic version of the IPAQ scale (www.IPAQ.ki.se) was used. The tool was used in sevrel research among Tunisians and covers three types of activities: vigorous-intensity activities, moderate-intensity activities and walking. Participants report the number of days per week and the number of minutes per day they spent on each activity [67, 68]. The score for each type of physical activity in Metabolic Equivalent intensity in minutes per week (MET-min/wk) is calculated by multiplying the number of minutes per week devoted to each category of activity by the MET value of this activity (walking=3 0.3 × minutes of walking × days of walking; moderate activity=4.0 × minutes of moderate activity × days of moderate activity; vigorous activity=8.0 × minutes of vigorous activity × days of vigorous activityFurthermore, the calculation of adequate vigorous activity was based on no less than three days of vigorous activity exceeding 20 min per day. The same is true for sufficiently moderate activity and walking, which was calculated based on a five-day minimum of at least 30 min of moderate-intensity walking per day. Based on the scoring protocol provided by the IPAQ (www.IPAQ.ki.se) [69], levels of physical activity can be divided into three categories: inactive, minimally active, and health-enhancing physically active. IPAQ has demonstrated robust psychometric characteristics that have been well established in a number of populations [70, 71], particularly in the Arab population [72].

The arabic version of the compulsive internet use scale (CIUS)

We used the version translated by the CISU Arabic language translation and back-translation method. This version was identical to the initial version of the instrument which is designed to assess the severity of Internet addiction and/or compulsive, pathological or other Internet use that could be considered problematic. The 14 items on the CIUS-14 range in frequency from 0 ("never") to 4 ("very often"). Higher scores indicate more severe PIUs; values range from 0 to 56. The original CIUS demonstrated sufficient concurrent, factorial, and validity as well as good reliability (Cronbach's alpha ranged between.89 and.90) [73].

Moreover, the Arabic version of the questionnaire demonstrated robust psychometric qualities with an internal consistency index that was satisfactory (α=0.78), while the exploratory factor analysis suggested a one-factor solution [74].

Statistical analysis

The open-source free software Jamovi (version 2.3.21.0, Australia) was used to examine the data. Descriptive statistics of the demographic data were produced for the

preliminary analysis, and assumptions about the normal distribution were confirmed.

We rigorously assessed the DASS-21 questionnaire's reliability, including total score, stress, depression, and anxiety subscales, along with CIUS, using Cronbach's alpha, McDonald's omega, and Guttman lambda 6. This comprehensive approach ensures a solid understanding of the instruments' consistency for future research and clinical applications.

The relationship between latent variables was evaluated by the Pearson correlation coefficients for DASS21 and CIUS SCORES. Moreover, Spearman coefficients was used to exam the relationships for gender and IPAQ. To examine these associations, we used low (<0.35), moderate (0.36–0.67), and strong (>0.67) thresholds for the correlation coefficient.

Seeing that the data did not deviate significantly from a normal distribution, correlation analysis using structural equation modelling (SEM) was performed.

We tested the structural model using the unweighted least squares. Several goodness-of-fit indices were used as criteria for the selection of the above model. We used $\chi 2/df < 5$, GFI, CFI, NFI, TLI > 0.90, SRMR, and RMSEA < 0.08 as the model fit index evaluation standards.

We performed bootstrapping with 5,000 samples for the analysis of moderate mediation considered the conditioning parameter from the mean and standard deviation (–1SD, +1SD) through the statistical package jamovi Advanced Mediation Models (JAMM).

We used a multinomial logistic regression to explore the effects of CIUS, Gender and IPAQ on the three mental health outcomes (stress, anxiety and depression).

Table 1 Sociodemographics, Internet main use, and physical activity practice

		n	%
Gender	Females	512	52,46
	Males	464	47,54
Economic Level	Low	256	26,23
	Medium	523	53,59
	High	197	20,18
Dwelling	Student housing	309	31,66
	With Family	328	33,61
	With freinds	339	34,73
Internet main use	Games	291	29,82
	Social Media	506	51,84
	Other use	179	18,34
IPAQ	Weak	389	39,86
	Moderate	434	44,47
	Vigourous	153	15,68

Results

Preliminary analysis

Table 1 indicates that there were 976 students who completed the questionnaires. The entire students meet the inclusion criteria and not have any problematic mental disoders according to DASS 21 scores. Participants' average ages were 20.76±1.63 years, with 52.46% (n=512) of them being female and 464 (47.54%) male. All participants were Muslims and had on-going access to the internet.

Students were divided according to economic levels into low (n=256, 26.23%), medium (n=523, 53.59%) and high (n=197, 20.18%). 31.66% of the students resided in university hostels, 34.73% with their families, while the rest of the students reside in rental houses with their colleagues.

Regarding the main use of the internet, 29.82% of the students declared that they use the internet to play games, 51.84% mainly use the internet to access social networks, while 18.34% of the students use the internet for other purposes such as watching online videos, gambling, learning and scientific researches.

Concerning the physical activity, 39.86% of the students practice a weak physical practice, 44.47% a moderate physical practice and 5.68% a rigorous physical practice.

The examination of the internal consistency reliability of the DASS-21 questionnaire and CIUS yielded excellent outcomes (see Table 2). Across various measures, the instruments demonstrated strong reliability. Cronbach's alpha, McDonald's Omega and Guttman Lambda 6 coefficients all exceeded the commonly recommended threshold of 0.80 for good, indicating high internal consistency. Overall, the comprehensive approach to reliability assessment underscores the excellent reliability of the DASS-21 and CIUS instruments.

As shown in Table 3, correlation coefficients indicate a moderate negative association between CIUS sores and IPAQ physical activity measurement (r=-0.49, p<0.01). Also, a moderate positive association was demonstrated between CIUS and DASS21 (r=0.54, p<0.01). While a weak correlation was demonstrated between CIUS and gender (r=-0.24, p<0.01). In addition, the results demonstrated a moderate negative relationship between IPAQ scores and DASS21 scores (r=-0.52, p<0.01) and an association between IPAQ scores and gender (r=0.31, p<0.01). On the other hand, gender was weakly associated with DASS21 scores (r=-0.16, p<0.01).

In the SEM analysis (Fig. 1), the goodness of fit indices of the study mediation model were found to be significant ($\chi 2$ (624, N=976)=2246; P<0.001; $\chi 2/df$=3.60; GFI=0.99; CFI=0. 97; NFI=0.96; TLI=0.97; SRMR=0.071; RMSEA=0.052 [0.049-0.054].

Table 2 Internal Consistency Reliabilty of DASS-21 and CIUS

Scale	Estimate	McDonald's ω	Cronbach's α	Guttman's λ6	mean	sd
CIUS	Point estimate	0.942	0.941	0.941	37.398	10.751
	95% CI lower bound	0.936	0.936	0.937	36.739	10.305
	95% CI upper bound	0.947	0.947	0.946	38.057	11.238
DASS-21	Point estimate	0.923	0.923	0.937	22.115	9.535
	95% CI lower bound	0.916	0.916	0.934	21.531	9.139
	95% CI upper bound	0.930	0.929	0.943	22.700	9.967
Depression	Point estimate	0.887	0.886	0.871	10.939	4.727
	95% CI lower bound	0.876	0.875	0.860	10.650	4.530
	95% CI upper bound	0.897	0.897	0.882	11.229	4.941
Anxiety	Point estimate	0.919	0.918	0.907	7.265	4.186
	95% CI lower bound	0.911	0.910	0.900	7.008	4.012
	95% CI upper bound	0.926	0.926	0.916	7.521	4.376
Stress	Point estimate	0.841	0.841	0.821	3.911	2.624
	95% CI lower bound	0.826	0.825	0.806	3.750	2.515
	95% CI upper bound	0.856	0.855	0.838	4.072	2.743

Table 3 Descriptive statistics and correlations coefficients

		CIUS	IPAQ	DASS21	M	SD	Skewness	Kurtosis
CIUS					2.80	0.81	0.16	-0.93
IPAQ	r	-0.49						
	p	$p < 0.01$						
DASS21	r	0.54	-0.52		1.09	0.46	0.07	-0.69
	p	$p < 0.01$	$p < 0.01$					
Gender	r	-0.24	0.31	-0.16				
	p	$p < 0.01$	$p < 0.01$	$p < 0.01$				

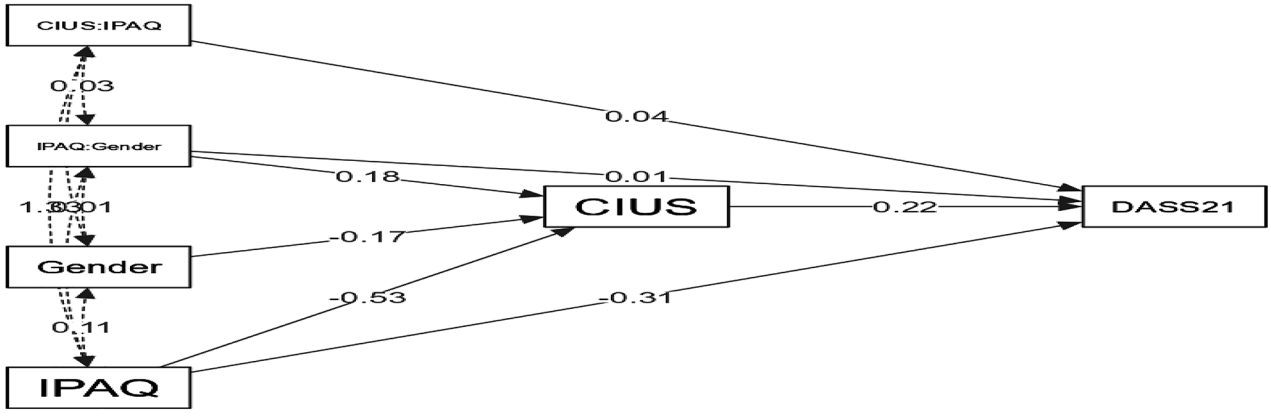

Fig. 1 Relationship between IPAQ, CIUS, Gender and DASS21 score's

Mediation effects

We provide an overview of all mediation effects in the path analysis in Table 4. All three predictor variables (IPAQ, Gender and CIUS) significantly affected DASS21 scores; IPAQ (ß = –0.46, $p \leq 0.01$), Gender (ß = –0.1, $p \leq 0.001$) and CIUS (ß = 0.39, $p \leq 0.01$).

Indirect effects of IPAQ and gender on DASS21 were highlighted: β= -0.18 ($p < 0.01$) and β= -0.04 ($P < 0.01$) respectively. In addition, a significant and negative effect of IPAQ on CIUS was demonstrated (β = -0.45, $P < 0.01$). In addition, the effect of CIUS on DASS21 was significant (β = -0.45, $P < 0.01$). Also, the effect of gender on CIUS was significant (β=-0.10, $P < 0.01$) However, its effect on DASS21 was not (β=0.05, $p = 0.078$). The total effect of IPAQ on DASS21 was significant (β= -0.52, $p < 0.01$) but the effect of Gender on DASS21 was not significant (β=0.01, $p = 0.817$).

Table 4 Direct and indirect effects

				95% C.I. (a)				
Type	**Effect**	**Estimate**	**SE**	**Lower**	**Upper**	**β**	**z**	**P**
Indirect	IPAQ ◊CIUS ◊ DASS21	-0,11	0,01	-0,14	-0,09	-0,18	-10,12	< 0.001
	Gender ◊CIUS ◊ DASS21	-0,04	0,01	-0,06	-0,02	-0,04	-3,45	< 0.001
Component	IPAQ ◊ CIUS	-0,52	0,03	-0,58	-0,45	-0,45	-15,55	< 0.001
	CIUS ◊ DASS21	0,22	0,02	0,19	0,25	0,39	13,34	< 0.001
	Gender ◊CIUS	-0,17	0,05	-0,26	-0,08	-0,10	-3,57	< 0.001
Direct	IPAQ ◊DASS21	-0,22	0,02	-0,26	-0,18	-0,34	-11,53	< 0.001
	Gender ◊ DASS21	0,04	0,02	0,00	0,09	0,05	1,76	0.078
Total	IPAQ ◊ DASS21	-0,34	0,02	-0,37	-0,30	-0,52	-17,94	< 0.001
	Gender DASS21	0,01	0,03	-0,05	0,06	0,01	0,23	0.817

Table 5 Moderation effects of gender and CIUS

Interaction	**Estimate**	**SE**	**Lower**	**Upper**	**β**	**z**	**p**
IPAQ: Genre CIUS	0,18	0,07	0,05	0,31	0,07	2,68	0.007
IPAQ: Genre DASS21	0,01	0,04	-0,06	0,09	0,01	0,34	0.736
Genre: CIUS DASS21	0,03	0,03	-0,04	0,09	0,09	0,86	0.390
IPAQ: CIUS DASS21	0.03	0.02	-0.01	0.07	0.14	1.58	0.115

Moderation

The results showed a significant moderation effect of the interaction between IPAQ and Gender on CIUS (β=0.07, $p<0.01$). However, it was not significant between Gender and CIUS on DASS21 (β=0.09, $p=0.390$) and between IPAQ and Gender on DASS21 (β=0.01, $p=0.736$) Also, the moderation effect was not significant in the interaction between IPAQ and CIUS on DASS21 (β=0.15, $p=0.115$) (see Table 5).

Higher Compulsive Internet Use Scale (CIUS) score correlates with an increased risk of adverse mental health outcomes (Table 6). For those classified with normal stress levels, each unit increase in CIUS is associated with a decrease in the odds (B = -0.506, SE=0.178, $p=0.004$, AOR=0.603, 95% CI [0.425, 0.854]), while for normal anxiety, the association shows a negative trend but is not significant (B = -0.238, SE=0.210, $p=0.257$, AOR=0.788, 95% CI [0.522, 1.190]). Higher CIUS scores are significantly associated with greater odds of moderate to severe stress (B=0.935, SE=0.138, $p<0.001$, AOR=2.546, 95% CI [1.943, 3.337]) and anxiety (B=0.719, SE=0.171, $p<0.001$, AOR=2.052, 95% CI [1.468, 2.869]). Low physical activity (IPAQ1) is linked with a higher likelihood of moderate to severe stress (B=1.600, SE=0.331, $p<0.001$, AOR=4.954, 95% CI [2.589, 9.480]), anxiety (B=1.610, SE=0.363, $p<0.001$, AOR=5.005, 95% CI [2.459, 10.185]), and depression (B=0.882, SE=0.355, $p=0.013$, AOR=2.417, 95% CI [1.206, 4.842]).

Discussion

The present study demonstrated that there was a significant and a strong positive correlation between the negative emotional state assessed by DASS 21 and the PIU. Our finding are in line with a previous study [75], which indicated that there was a significant and strong positive correlation between mental health assessed by the Mental Health Inventory and PIU, while [76] showed a statistically significant weak relationship between psychological health evaluated by the General Health Questionnaire and PIU.

According to our model, there were overall associations between PIU and negative emotional state issues, which was consistent with the findings of earlier research [77–81, 81, 82]. For example, a recent study conducted on 524 students (78.60% female, mean age 24 [SD 3] years old) demonstrated that the severity of PIU was linked to a number of mental health issues [80].

The present study showed that the relationship between negative emotional state levels and PIU among college students are directly proportional.

Other previous studies have also found positive correlations between PIU and stress. A recent investigation of 433 Turkish students revealed an increase in stress levels among students as the level of PIU increased [83]. To manage negative emotions, students use their smartphones to access the Internet. Playing and chatting online is going to make this internet use problematic [84]. In addition, a Chinese study proved that students who are under stress use the Internet in a problematic way [85].

Expanding on these findings, it becomes evident that the relationship between PIU and stress is multifaceted and warrants further exploration. For instance, while the Turkish study highlights a direct correlation between PIU and stress levels, it is essential to delve deeper into the underlying mechanisms driving this association. According to Carmona [86], the escapism offered by

Table 6 Multionomial Logistic regression for stress depression, and anxiety

			B	Wald	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
							Lower Bound	Upper Bound
Stress	Normal	Intercept	2,07	23,59	0,000			
		CIUS	-0,51	8,08	0,004	0,60	0,42	0,85
		[Gender = F]	0,05	0,05	0,822	1,05	0,68	1,64
		[Ipaq = Low]	-1,46	15,40	0,000	0,23	0,11	0,48
		[Ipaq = Moderate]	-1,23	22,49	0,000	0,29	0,18	0,49
	Moderate-Severe	Intercept	-2,25	29,26	0,000			
		CIUS	0,93	45,89	0,000	2,55	1,94	3,34
		[Gender = F	-0,08	0,19	0,660	0,92	0,64	1,33
		[Ipaq = Low]	1,60	23,35	0,000	4,95	2,59	9,48
		[Ipaq = Moderate]	0,52	3,25	0,072	1,69	0,96	2,98
Anxiety	Normal	Intercept	1,20	6,21	0,013			
		CIUS	-0,24	1,28	0,257	0,79	0,52	1,19
		[Gender = F]	-0,48	2,93	0,087	0,62	0,36	1,07
		[Ipaq = Low]	0,20	0,24	0,626	1,23	0,54	2,78
		[Ipaq = Moderate]	-0,29	0,85	0,356	0,75	0,41	1,38
	Moderate-Severe	Intercept	-0,74	3,03	0,082			
		CIUS	0,72	17,67	0,000	2,05	1,47	2,87
		[Gender = F]	-0,31	1,73	0,188	0,74	0,47	1,16
		[Ipaq = Low]	1,61	19,73	0,000	5,00	2,46	10,18
		[Ipaq = Moderate]	0,94	11,25	0,001	2,55	1,48	4,41
Depression	Normal	Intercept	2,39	46,01	0,000			
		CIUS	-0,44	12,89	0,000	0,64	0,51	0,82
		[Gender = 1]	0,02	0,01	0,907	1,02	0,72	1,45
		[Ipaq = Low]	-0,91	9,74	0,002	0,40	0,23	0,71
		[Ipaq = Moderate]	-0,52	4,08	0,043	0,59	0,36	0,98
	Moderate-Severe	Intercept	-0,69	2,73	0,098			
		CIUS	0,17	1,93	0,164	1,19	0,93	1,52
		[Gender = F]	-0,11	0,35	0,556	0,90	0,62	1,29
		[Ipaq = Low]	0,88	6,19	0,013	2,42	1,21	4,84
		[Ipaq = Moderate]	0,54	2,56	0,110	1,71	0,89	3,30

Footnote: Gender male = reference, Vigorous physical activity = reference, Mild stress = reference, Mild Anxiety = reference, Mild Depression = reference

online activities, provides temporary relief from stressors but ultimately perpetuates a cycle of dependence and heightened stress. Additionally, cultural factors and societal norms surrounding technology usage may play a significant role in shaping individuals' susceptibility to PIU under stress [87]. In addition, several previous studies suggest associations between depression and PIU [76, 88–91]. For example, a study conducted on Chinese college students found that increased internet usage time is associated with a higher level of depression scores among Chinese college students [91]. Similarly, a recent cross-sectional study of 619 university students (92.9% female and 7.1% male) with an average age of 22 ± 3 years demonstrated that depressive symptoms were significantly higher among students with PIU. In other words, the results of structural equational modeling analysis revealed that PIU significantly influences depressive symptoms [45].

Brailovskaia and Margraf [92] suggests that excessive internet use, characterized by PIU, can lead to a sedentary lifestyle, thereby reducing the likelihood of engaging in regular physical activity. Individuals who spend significant amounts of time online may prioritize screen time over exercise, leading to decreased physical activity levels. This sedentary behavior can contribute to physical health problems such as obesity, cardiovascular issues, and muscular-skeletal disorders, all of which can exacerbate symptoms of depression.

Conversely, regular physical activity has been shown to have a positive impact on mental health, including reducing symptoms of depression. Exercise triggers the release of endorphins, neurotransmitters that promote feelings of well-being and happiness, while also reducing levels of stress hormones like cortisol. Engaging in physical activity can provide a healthy outlet for managing stress and negative emotions, potentially mitigating the risk of developing depression [93].

Also, previous studies have advanced the theory that anxious people use online interactions to compensate for poor real-life relationships and shown a strong

association between PIU and anxiety symptoms [6, 94]. In contrast, previous studies have found no links between PIU and symptoms of anxiety [76, 95, 96].

Additionally, according to Svensson and all [97]., regular physical activity has been demonstrated to positively impact anxiety levels. Exercise triggers the release of endorphins, chemicals in the brain that promote feelings of well-being and relaxation, while also reducing levels of stress hormones such as cortisol. Participating in physical activity can serve as a constructive outlet for managing stress and anxiety, potentially alleviating symptoms.

A number of studies have found a link between mental health quality and physical activity [98–103] and highlited that poor mental health was related to weak physical activity [104]. Our present research agrees with a previous study [105] and reveals that physical activity had a decisive moderating role in the link between PIU and the negative emotional state of university students. In other words, students who have a higher PIU are also more likely to have unfavorable negative emotional state indices, which is partly explained by lower levels of physical activity.

Our study agrees with previous research [106–108] stating that PIU can impact the prevalence of physical activity. For example, the results of the study by [106] reinforce the results of the present study by revealing that there is a significant correlation between physical activity levels and PIU. The results indicate that the scores of the Cognitive-Behavioral Physical Activity Questionnaire are observed to be significantly lower in participants who spend more of their free time on the Internet compared to those who spend their free time playing sports [106]. Similarly, the authors showed that participants who spend their time playing sports are likely to express a lower PIU than those who spend their free time on the Internet. On the other hand, a recent study conducted on a sample of Vietnamese university students revealed that Internet addiction has no effect on sports practice [109].

Several previous studies have found a correlation between gender and severity of PIU. A recent meta-analytic study reported an overall gender difference [110]. The results of the present study agree with other previous studies and reveal that women are likely to express a higher PIU than men [111–113]. For example, Casaló & Escario [111] and Machimbarrena et al. [113] reported that Spanish women outscored men on PIU severity however, the present study departs from earlier surveys that have suggested a propensity for men to exhibit a higher level of problematic Internet use (PIU) compared to women [114–119]. For example, a study in populations from the United States, United Kingdom and Australia found that women had significantly lower scores in terms of PUI severity compared to men [114].

Our study highlighted a role of physical activity moderation on the association between PIU and negative emotional state outcomes measured on the DASS21. In contrast, no such moderating effect was found for the relationship between physical activity and negative emotional state parameters. Similarly, gender did not act as a moderating variable for the relationship between physical activity and PIU.

In line with these results, a moderation analysis indicated that physical exercise moderated the relationship between PIU and psychological symptoms [120].

Our study could not highlight the role of gender as a moderator between physical practice and negative emotional state. In contrast, gender appears to be a moderator between physical activity and mental health in adolescents [121].

Furthermore, other previous research contradicts our results and claims to find no significant associations between gender and PIU severity [122–127]. However, to best our knowledge, no moderation effect has been examined in previous studies.

The results of this research indicate that the practice of physical activity among Tunisian women is lower than that of men. Our results agree with those of other previous studies [128–131]. For example, a recent study conducted on an Arabic sample revealed that gender differences in the prevalence of physical activity were evident [130]. Likewise, a previous study demonstrated that Saudi men have been shown to be more active than women [129]. Moreover, cross-cultural studies have revealed that young Arab women are less active than British ones [128, 131].

Limitation of study

Our study has several limitations

The first limitation concerns the cross-sectional design of the study, which may limit the generalizability of the results. In addition, the snowball sampling method and the line design may prove to have methodological limitations.

PIU may vary by gender, as previous studies have suggested that women use social media heavily while men use the internet more for gambling. Future studies should incorporate questionnaires that involve gaming disorders and social media addiction.

The current study did not control for mental health disorders and medication use among participants. these variables may affect the association between physical practice, PIU, and negative emotional state. A question regarding mental health problems and medication use should be considered in previous research in this topic.

Finally, previous studies have found that the mental health measurement tools used influence the results of associations between PIU and mental health indicators

[132, 133]. Therefore, it is necessary to use other measures of negative emotional state other than the DASS21.

Conclusion

Our finding proved the relationship between the practice of physical activity and PIU. Also, physical practice appears to moderate the link between PIU and mental health. While gender was linked to PIU. In addition, a direct association of PIU with mental health outcomes has been demonstrated.

Abbreviations

DASS-21	The depression, anxiety and stress scale– 21 items
IPAQ	The international physical activity questionnaire
CIUS	The compulsive internet use scale
PIU	Problematic Internet Use
IP	Internet Protocol
JAMM	Statistical package jamovi Advanced Mediation Models
χ2	Chi-Square
GFI	The goodness of fit index
CFI	The comparative fit index
NFI	Normed Fit Index
TLI	Tucker-Lewis index
SRMR	Standardized Root Mean Square Residual
RMSEA	Root mean square error of approximation

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

HJ took on the role of research design, field survey supervision, data management, statistical analyses, and paper writing, with primary responsibility for the final content. MBA also contributed to the research design, data management, statistical analyses, and paper writing. NK contributed to the research design and had primary responsibility for the final content. MS played a role in data management, statistical analyses, and paper writing. NG was involved in data management and statistical analyses. NLB supervised the field survey. TB contributed to the research design and supervised the data management. FFK provided supervision for the research design and manuscript revision. ID took on the responsibilities of paper writing and field survey supervision. All authors participated in the critical revision of the manuscript, and they read and approved the final version.

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Data availability

The datasets utilized and/or examined in this study can be obtained from the corresponding author upon a reasonable request.

Declarations

Competing interests

The authors declare no competing interests.

Ethical approval and consent to participate

The study design protocol adheres to the guidelines set forth by the Declaration of Helsinki for human experimentation, receiving official approval from the Ethics Committee of the University of Jendouba in Tunis, Tunisia, with the assigned number 30/2023. Prior to the collection of data, all participants willingly joined the study and gave informed consent, ensuring their understanding and agreement before enrolling in the study protocol.

Consent for publication

Not applicable.

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