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Recurrent pain symptoms among adolescents with generalized and specific problematic internet use: A large-scale cross-sectional study

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ABSTRACT

Numerous studies suggest a negative impact of problematic internet use (PIU) not only on mental health but also on somatic components of adolescent health. The present study aimed to identify the associations between different types of PIU – generalized PIU (GPIU), problematic video game use (PVGU), and problematic social media use (PSMU) – and recurrent pain symptoms (headache, abdominal pain, and back pain), as well as to determine the role of psychosocial factors in these associations. In a cross-sectional school-based study, 4411 urban Siberian adolescents were asked about the presence, frequency, and intensity of pain symptoms in the past three months. Standardized psychometric scales were used to assess GPIU, PSMU and PVGU. Given the presence of psychosocial problems as a major confounder, direct associations of PSMU and GPIU with recurrent pain symptoms (headache, abdominal pain, and back pain) were found. PVGU was weakly associated only with abdominal pain. Further analysis indicated that the positive associations were largely mediated by comorbid psychosocial problems. These findings highlight the importance of addressing both problematic internet use and comorbid psychosocial problems to effectively reduce PIU-associated recurrent headaches, abdominal pain, and back pain among adolescents.

1. Introduction

Recurrent pain symptoms, such as headache, abdominal pain, and back pain, are common among the adolescent population. These symptoms can significantly interfere with daily activities, lead to school absenteeism and poor academic performance, and pose significant public health problems (Kolb et al., 2022; Krause et al., 2019; Ragnarsson et al., 2020; Roth-Isigkeit et al., 2005). Epidemiological studies indicate that 15%–25% of adolescents suffer from at least one recurrent pain condition (King et al., 2011; Kolb et al., 2022; Perquin et al., 2000).

From the onset of studies in the mid-1990s to the present day, efforts have been made to assess its negative impact of internet use on children and adolescents, primarily concerning mental health and social functioning, as well as somatic health components and well-being. Recent systematic reviews and meta-analysis have shown a significant reduction in both psychological and somatic components of life quality among adolescents and young adults with problematic internet use and smartphone use (Masaeli & Billieux, 2022; Noroozi et al., 2021). Problematic internet use (PIU) can negatively affect the health-related quality of life among the adolescent population (Machimbarrena et al., 2019). Generalized psychosomatic complaints have been positively associated with problematic social media use (PSMU) and PIU in a representative sample of adolescents in Luxembourg and among Chinese students (Cao et al., 2011; van Duin et al., 2021). General somatization has been associated with PIU among young adults in Italy and Taiwan (Wei et al., 2012; Zamboni et al., 2020). PSMU has also been associated with multiple somatic symptoms (a combination of headaches, abdominal pain, back pain, and dizziness) in a representative sample of Italian adolescents (Marino et al., 2020).

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1.1. Recurrent headache and problematic internet use

Recurrent headache (RH) is the most common psychosomatic complaint among adolescents, being a symptom of nosologies such as tension-type headache (17% of the adolescent population) and migraine (11% of the adolescent population) (Onofri et al., 2023). A number of studies have shown an association between PIU and headache. For instance, Paakkari et al. (2021) reported a progressive increase in headache incidence in parallel with the increased PSMU in a representative sample of Finnish adolescents. Associations between generalized PIU and headache have previously been reported in Polish, Turkish and Brazilian students (Bener et al., 2019; Corrêa Rangel et al., 2022; Średniawa et al., 2015).

Indirect evidence of the association between headaches and PIU comes from studies evaluating the relationship between intensity of internet use, smartphone use, and personal computer use and headaches (Abir et al., 2021; Harris et al., 2012; Jain et al., 2023; Özdil et al., 2022; Stiglic et al., 2022; Xavier et al., 2015). However, some studies have shown no direct associations. For instance, Uttarwar et al. (2020) found no association between smartphone use and headaches, although active smartphone users were more likely to use medications for pain management. Cerutti et al. (2016) did not find a significant association between the intensity of internet/smartphone use and tension-type/migraine headaches, although somatic symptoms were reported more frequently among those with PIU. Langdon et al. (2022) reported that the mean monthly incidence of headaches among adolescents showed no significant association with the type or duration of screen exposure to digital devices. Turkish researchers described a paradoxically low frequency of PIU among children with headaches compared to the control group (Tepecik Böyükbaş et al., 2019). The conflicting results may stem from varying criteria used for RH and PIU, as well as gender and age differences in the samples.

1.2. Recurrent abdominal pain and problematic internet use

Recurrent abdominal pain (RAP) among adolescents is predominantly psychosomatic, and part of functional dyspepsia and irritable bowel syndrome diagnoses (Chen et al., 2023; Sjölund et al., 2021). According to a meta-analysis by Korterink et al. (2015), the average prevalence of functional abdominal pain disorders among children and adolescents is 13.5%, with a predominance of females and a significant association with anxiety, depression, stress, and traumatic life events. Current evidence on the association between RAP and PIU is limited. Harris et al. (2012) demonstrated a significant positive association between the frequency and duration of home computer use and RAP among children and adolescents aged 6–16 years. Cinquetti et al. (2021) reported an association between problematic smartphone use and functional gastrointestinal disorders among adolescents. The association of PIU with misperception of body image (Bozzola et al., 2022), eating disorders (Hinojo-Lucena et al., 2019; Kożybska et al., 2021), irrational diet (Bozzola et al., 2022; Kim et al., 2010), obesity (Eliacik et al., 2016), constipation (Çakar & Eren, 2023), and nausea (Mei et al., 2022), described in several studies, might also suggest an association between PIU and RAP, given the presence of common pathogenetic mechanisms.

1.3. Recurrent back pain and problematic internet use

Recurrent back pain (RBP) can significantly disrupt daily life and represents a health problem not only for adults but also for children, particularly during adolescence (Jones & Macfarlane, 2005; MacDonald et al., 2017). The prevalence of low back pain among the child and adolescent populations is notably high ranging from 17.7% (one week prevalence) to 39.9% (lifetime prevalence) (Calvo-Muñoz et al., 2013). The monthly prevalence of RBP ranges from 18% to 24% (Kamper et al., 2016). The main established risk factors for non-specific RBP among adolescents include being female, having psychological issues (such as low life satisfaction, low self-esteem, anxiety, depression), and low physical activity level (Frosch et al., 2022; Kolb et al., 2022; Stanford et al., 2008). Numerous studies have also highlighted the association between RBP and the excessive use of personal computers/smartphones and PIU (Abir et al., 2021; Alsalameh et al., 2019; Ayhualem et al., 2021; Mustafaoglu et al., 2021; Paakkari et al., 2021; Yang et al., 2019; Özdil et al., 2022; İnal & Serel Arslan, 2021). For example, Suris et al. (2014) found that PIU among adolescents was associated with back pain, musculoskeletal pain, being overweight, and sleep disturbances.

1.4. Unresolved issues in the association between problematic internet use and recurrent pain symptoms

An important consideration in assessing the association between PIU and recurrent pain symptoms is the role of psychological problems within the anxiety-depressive spectrum (including anxiety, depression, phobic disorders, and obsessive-compulsive disorder) as common risk factors. The validity of these associations has been established for different types of PIU (Andreassen et al., 2016; Fineberg et al., 2022; Ho et al., 2014; Huang, 2022; Ostinelli et al., 2021; Rathod et al., 2022) as well as for recurrent pain symptoms – RH (Abu-Arafeh, 2023; Blaauw et al., 2014; O'Brien & Slater, 2016), RAP (Korterink et al., 2015) and RBP (Frosch et al., 2022). Therefore, the previously described associations between PIU and RH, RAP, and RBP may be falsely positive in terms of causality, reflecting a common confounder – psychosocial problems. This confounder could distort direct causality, leading to overestimated or underestimated associations. To the best of the present authors' knowledge, no previous study has ever examined this aspect explicitly – none of the aforementioned studies investigated the role of psychosocial problems as a potential common cofactor of PIU, RH, RAP, and RBP. Therefore, the present study aimed to address this major limitation.

Another challenge in evaluating these associations is the heterogeneity within the PIU group. Davis (2001) proposed distinguishing between generalized PIU (GPIU) and its specific forms within a cognitive-behavioral model, notably problematic videogame use (PVGU) and problematic social media use (PSMU). Studies indicate that these forms of addictive online behavior show low intercorrelation concerning age-sex demographics, psychological characteristics, and the digital devices accessed (Balhara et al., 2021; Griffiths, 2018; Király et al., 2014; Ryding & Kaye, 2018). This distinction allowed the present authors to identify two patterns of psychosocial problems associated with PIU among adolescents: one specific to GPIU and PSMU, and another, markedly different, related to PVGU (Sánchez-Fernández et al., 2024; Tereshchenko et al., 2022). Importantly, when considering the association of recurrent pain symptoms, it is necessary to account for the type of content consumed, with separate assessments for GPIU, PVGU, and PSMU. To date, this approach has been rarely implemented, except in a small-sample study on the relationship between PIU and migraines (Gautam et al., 2022).

1.5. Hypotheses

Based on the findings of the aforementioned literature, the present study tested the following hypotheses (H_s). It was hypothesized that (i) recurrent pain symptoms would be positively associated with the prevalence of PIU among school samples of adolescent populations. More specifically, it was hypothesized that higher levels of GPIU, PVGU, and PSMU would be positively associated with greater frequency and intensity of recurrent pain symptoms (H_1); (ii) the strength of the association between PIU and recurrent pain symptoms would vary based on the type of PIU and recurrent pain symptoms localization, given the role of psychosocial problems as a probable common confounder (H_2); and (iii) psychosocial problems may partially mediate the associations between different types of PIU and pain symptoms, with varying direct and indirect effects across GPIU, PVGU, and PSMU (H_3).

2. Methods

2.1. Participants

The present study comprised a cross-sectional survey of a school sample in three large cities in Central Siberia (Russia). All of the school students asked to participate (N = 4838) agreed to do so. Therefore, the initial response rate was 100%. However, 427 adolescents did not provide complete demographic data (sex, age, ethnicity) or did not complete all the psychometric scales (8.8%), therefore the final sample for analysis comprised 4411 adolescents (aged 12–18 years). The students came from ten comprehensive schools in Krasnoyarsk (n = 2843), four comprehensive schools in Abakan (n = 1357), and two comprehensive schools in Kyzyl, (n = 211). Schools were selected by sending invitations to the administration of all public schools in each city. All schools that agreed to be surveyed were included. Schools with special educational conditions (boarding schools, cadet schools, and schools for adolescents with special health conditions) were excluded to ensure homogeneity of the sample (because these schools may have had different health requirements for admission, different daily routines for students, and different levels of physical activity). The response rates for the schools who were approached to participate were 8.9% for schools in Krasnoyarsk (10/112), 5.0% for Abakan (4/80), and 2.7% for Kyzyl (2/73).

2.2. Procedure

After obtaining informed consent from the parents and confirming the voluntary nature of participation with the students, the researchers assured the latter of the confidentiality of the study. The students were asked to complete paper versions of self-report questionnaires (that took a maximum of 45 min to complete) in a classroom setting. The survey was conducted in the spring of 2019. The study was approved by the Ethics Committee of the Federal Research Centre (Krasnoyarsk Science Center of the Siberian Branch of the Russian Academy of Sciences; Ref: 12–2018).

2.3. Measures

2.3.1. Demographic variables

Demographic data such as sex, age, place of residence, and ethnicity were included in the survey.

2.3.2. Recurrent pain symptoms

Adolescents were asked a number of questions regarding the presence, frequency and intensity of pain symptoms in the past three months. The criteria for inclusion in recurrent headache (RH), recurrent abdominal pain (RAP), and recurrent back pain (RBP) groups for all types of pain were as follows: pain episodes 3 or more times per month within the past three months irrespective of pain intensity OR 1–2 times per month with pain ≥4 points using the Wong-Baker FACES Pain Rating Scale (with scale values ranged from 0 to 5 points) (Wong & Baker, 1988).

2.3.3. Problematic internet use

The Chen Internet Addiction Scale (CIAS) was used to assess PIU (Chen et al., 2003; Russian version: Malygin, 2011). The CIAS assesses five symptomatic criteria of addictive behavior (compulsive internet use, withdrawal, tolerance, interpersonal and health problems, and time management problems). The scale comprises 26 items (e.g., *"I find myself going online instead of spending time with friends"*), each rated on a four-point scale: 1 (*does not match at all*), 2 (*weakly matches*), 3 (*partially matches*), and 4 (*completely matches*). A total CIAS score of ≥65 is considered indicative of generalized PIU (GPIU).

PVGU and PSMU were assessed using the Russian versions of the Game Addiction Scale for Adolescents (Tereshchenko & Gorbacheva, 2024a) and the Social Media Disorder Scale (Tereshchenko et al., 2024b), respectively. The Game Addiction Scale for Adolescents (GASA) (Lemmens et al., 2009) comprises seven items that assess PVGU. Each item (e.g., *"How often during the last six months did you think about playing a game all day long?"*) is responded to with the following options: "never, " "rarely," "sometimes," "often," and "very often." According to the criteria provided by the authors (Lemmens et al., 2009), and using a polythetic assessment, adolescents are classed as having PVGU if they respond "sometimes", "often", or "very often" to any 4 or more out of the 7 items. The Social Media Disorder Scale (SMDS) (Van Den Eijnden et al., 2016) comprises nine items that assess PSMU. Each item (e.g., *"During the past year have you often felt bad when you could not use social media?"*) has two answer options: "no" and "yes". Five or more affirmative responses out of nine suggest the presence of PSMU.

2.3.4. Psychosocial problems

The Strengths and Difficulties Questionnaire (SDQ) (Goodman et al., 1998) was used to assess psychosocial problems among adolescents over a six-month period (Russian versions (Ruchkin et al., 2007; Slobodskaya et al., 2007). The SDQ comprises 25 items (e.g., *"Other people my age generally like me"*) and are responded to on a three-point scale: 0 (*not true*), 1 (*somewhat true*), and 2 (*certainly true*). Scores are assigned in either a forward or reverse order for each item, and are categorized into five scales (emotional symptoms, hyperactivity/inattention, conduct problems, peer problems, and prosocial behavior). A total score is calculated by summing the scores from the first four scales. A higher score indicates greater severity of mental health and behavioral problems. The psychometric characteristics of all the instruments included in the present study are shown in Table 1.

2.4. Statistical analysis

The minimum required sample size (n = 1383) was calculated, taking into account the likely prevalence of PIU at 10%, effect size at .5 (medium), power at 80% (.8), and significance level (α) at .05. Therefore, the number of participants in the present study was more than sufficient. The statistical analysis was performed using IBM SPSS Statistics for Windows, v26.0 (IBM Corp, Armonk, NY). The confirmatory factor analysis was performed using R with the lavaan package (Rosseel, 2012) and implemented using the Jamovi graphical interface v2.2.5 (Şahin & Aybek, 2020). The quality of the model fits was assessed using the following indicators: χ^2, the root mean square error of approximation (RMSEA), the comparative fit index (CFI), and the Tucker–Lewis index (TLI). The cut-off values for adequate model fit were as follows: RMSEA <.08, CFI ≥.90, and TLI ≥.90 (Hu & Bentler, 1999). Odds ratios (ORs) were calculated using multiple logistic regression and adjusting for covariates. Multiple linear regression analysis was used to explore whether independent variables (age, sex, CIAS, GASA, and SMDS) could predict the dependent variables (intensity of RH, RAP, and RBP). Mediation analysis was performed using Hayes' PROCESS macro for SPSS (Clement & Bradley-Garcia, 2022). The comparison of groups by the qualitative binary data was performed using the Pearson χ^2 test with Yates correction.

3. Results

3.1. Descriptive statistics

The original sample comprised 4838 adolescents (2048 boys [46.4%] and 2363 girls [53.6%]). After excluding those who were unable to complete all sections of the survey (n = 427; 8.8%), the sample size was reduced to 4411 adolescents. The mean age of the participants was 14.53 years (SD ± 1.52). The participants lived in three large cities in Central Siberia: 64.4% in Krasnoyarsk, 30.8% in Abakan, and 4.8% in Kyzyl. Additionally, data on the ethnic composition of the sample were collected, with 78.6% identifying as Russian, 8.7% as Khakas, 3.7% as Tuvan, and 9.0% as other ethnic groups (Table 2). The descriptive

Table 1
Psychometric characteristics of the questionnaires included in the study.

Instrument	Cronbach's alpha	McDonald's omega	χ^2 df, p	CFI	TLI	RMSEA (90% CI)
Chen Internet Addiction Scale (CIAS) (five-factor structure)	.909	.911	4481 265, <.001	.866	.848	.060 (.059–.062)
Game Addiction Scale for Adolescents (GASA) (one-factor structure)	.917	.924	658 14, <.001	.969	.953	.102 (.096–.109)
Social Media Disorder Scale (SMDS) (one-factor structure)	.679	.693	472 27, <.001	.895	.860	.061 (.056–.066)
Strengths and Difficulties Questionnaire (SDQ) (five-factor structure)	.657	.669	8272 275, <.001	.788	.760	.055 (.053–.056)

Note: CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation; CI = confidence interval.

Table 2
Descriptive statistics for major study variables (N = 4411).

Variables	All participants	Boys	Girls	p (boys vs. girls)
Age 12–14 years	2168	983 (45.3%)	1185 (54.7%)	–
Age 15–18 years	2243	1065 (47.4 %)	1178 (52.6%)	–
Total	4411	2048 (46.4%)	2363 (53.6%)	–
Residence (city)				
Krasnoyarsk	2843	1305 (45.9%)	1538 (54.1%)	–
Abakan	1357	653 (48.1%)	704 (51.9%)	–
Kyzyl	211	90 (42.6%)	121 (57.4%)	–
Ethnicity				
Russian	3466	1623 (46.8%)	1843 (53.2%)	–
Khakass	387	174 (45.0%)	213 (55.0%)	–
Tuvan	162	65 (40.1%)	97 (59.9%)	–
Other	396	186 (47.0%)	210 (53.0%)	–
Chen Internet Addiction Scale (CIAS) results				
Generalized problematic internet use (GPIU)	319 (7.2%)	107 (5.2%)	212 (9.0%)	<.001 $\chi^2 = 22.4$
Gaming Addiction Scale for Adolescents (GASA) results				
Problematic videogame use (PVGU)	461 (10.5%)	321 (15.7%)	140 (5.9%)	<.001 $\chi^2 =$ 110.4
Social Media Disorder Scale (SMDS) results				
Problematic social media use (PSMU)	349 (7.9%)	69 (3.4%)	280 (11.9%)	<.001 $\chi^2 =$ 107.1
Strengths and Difficulties Questionnaire (SDQ) results				
Total difficulties score ≥17	777 (17.6%)	277 (13.5%)	500 (21.2%)	<.001 $\chi^2 = 43.5$
Emotional symptoms score ≥7	494 (11.2%)	95 (4.6%)	399 (16.9%)	<.001 $\chi^2 =$ 165.5
Hyperactivity score ≥7	312 (7.1%)	115 (5.6%)	197 (8.3%)	.001 $\chi^2 = 12.0$
Conduct problems score ≥5	382 (8.7%)	194 (9.5%)	188 (8.0%)	.083 $\chi^2 = 3.0$
Peer problem score ≥6	331 (7.5%)	137 (6.7%)	194 (8.2%)	.064 $\chi^2 = 3.4$
Prosocial behavior score ≤4	495 (11.2%)	286 (14.0%)	209 (8.8%)	<.001 $\chi^2 = 28.4$
Recurrent pain symptoms				
Headache	1704 (38.6%)	543 (26.5%)	1161 (49.1%)	<.001 $\chi^2 =$ 235.8
Abdominal pain	636 (14.4%)	155 (7.6%)	481 (20.4%)	<.001 $\chi^2 =$ 144.3
Back pain	826 (18.7%)	267 (13.0%)	559 (23.7%)	<.001 $\chi^2 = 80.6$

Note: Data are presented as n (%). Pearson χ^2 test with Yates correction was used.

statistics for generalized and specific PIU behaviors (GPIU, PVGU, and PSMU), as well as the SDQ test scores and frequencies of recurrent pain symptoms frequencies (RH, RAP, and RBP), are shown in Table 2.

3.2. Prevalence and sex-related characteristics of major study variables

The prevalence of GPIU, as estimated using CIAS, was 7.2% in the total sample and proved to be higher among girls compared to boys (9.0% vs. 5.2%, $p < .001$; Table 2). The prevalence of PVGU estimated with the use of the GASA was 10.5% in the total sample and more than twice as high among boys compared to girls (15.7% vs. 5.9%, $p < .001$). The prevalence of PSMU estimated with the use of the SMDS was 7.9% in the total sample and more than three times higher among girls compared to boys (11.9% vs. 3.4%, $p < .001$).

In the total sample, using the SDQ, girls exhibited higher total psychosocial difficulties scores, as well as emotional symptoms and hyperactivity scores. Boys exhibited higher frequencies of low prosocial behavior. Additionally, there was a tendency towards higher frequencies of behavioral problems among boys ($p = .083$) and more frequent peer problems among girls ($p = .064$) (Table 2). The prevalence of (i) RH was 38.6%, (ii) RAP was 14.4%, and (iii) RBP was 18.7%. All types of recurrent pain symptoms were more common among girls.

3.3. Comorbidity of problematic internet use with recurrent pain symptoms

3.3.1. Multinomial logistic regression

To evaluate the association of the frequency of recurrent pain symptoms with different forms of PIU, two multinomial logistic regression models were employed – Model 1, which did not include SDQ test scores, and Model 2, which incorporated SDQ total scale scores. The results are presented in Tables 3 and 4, respectively.

In Model 1, unadjusted data showed significant associations of RH, RAP and RBP with GPIU and PSMU, but not with PVGU. After adjusting for sex, age, residence, and ethnicity, associations were found to be significant for all types of PIU, including PVGU (Table 3). The highest OR values were observed for RAP across all PIU types (GPIU OR = 2.57, CI = 1.98–3.35; PVGU OR = 1.82, CI = 1.39–2.38; PSMU OR = 2.42, CI = 1.88–3.11).

In Model 2, after adjusting for the factors described above and considering the presence of psychosocial problems as the most crucial cofactor, the associations with all recurrent pain symptoms remained significant only for GPIU and PSMU (Table 4). In this model, PVGU was weakly associated only with RAP (OR = 1.35, CI = 1.02–1.79) and showed no significant association with RH and RBP. The inclusion of comorbid psychosocial problems in the model significantly reduced all association coefficients by more than 10%, highlighting this factor as a significant confounder.

The results of the multinomial logistic regression showed that H_1 and H_2 were fully supported regarding the association of recurrent pain symptoms sufficient (according to the criteria used) frequency with PIU and the different patterns of these associations according to the type of PIU (GPIU, PVGU and PSMU). H_3 was partially supported regarding the

Table 3
Multinomial logistic regression estimates for recurrent pain symptoms according to generalized and specific problematic internet use among adolescents. Model 1 (crude and adjusted odds ratios) (N = 4411).

	Recurrent headache			Recurrent abdominal pain			Recurrent back pain		
	OR crude	OR adjusted Model 1	*p*	OR crude	OR adjusted Model 1	*p*	OR crude	OR adjusted Model 1	*p*
Generalized problematic internet use (CIAS score)	2.07 1.64–2.60	1.88 1.48–2.38	**< .001**, both for crude and adjusted	2.83 2.19–3.66	2.57 1.98–3.35	**< .001**, both for crude and adjusted	2.48 1.94–3.17	2.32 1.81–2.98	**< .001**, both for crude and adjusted
Problematic videogame use (GASA score)	1.08 .89–1.32	1.45 1.18–1.78	crude = .424 adjusted **< .001**	1.28 .99–1.66	1.82 1.39–2.38	crude = .059 adjusted **< .001**	1.25 .99–1.58	1.57 1.23–2.00	crude = .065 adjusted **< .001**
Problematic social media use (SMDS score)	2.31 1.85–2.89	1.85 1.47–2.32	**< .001**, both for crude and adjusted	3.00 2.35–3.83	2.42 1.88–3.11	**< .001**, both for crude and adjusted	2.46 1.94–3.12	2.15 1.69–2.74	**< .001**, both for crude and adjusted

Note: CIAS = Chen Internet Addiction Scale, GASA = Game Addiction Scale for Adolescents, SMDS = Social Media Disorder Scale, OR = Odds Ratio. ORs with 95% confidence intervals are shown. Crude ORs were adjusted for sex, age, residence (Krasnoyarsk, Abakan, Kyzyl), and ethnicity (Russians, Khakass, Tuvans, Others).

Table 4
Multinomial logistic regression estimates for recurrent pain symptoms according to generalized and specific problematic internet use among adolescents, Model 2 (adjusted odds ratios) (N = 4411).

	Recurrent headache		Recurrent abdominal pain		Recurrent back pain	
	OR adjusted Model 2	*p*	OR adjusted Model 2	*p*	OR adjusted Model 2	*p*
Generalized problematic internet use (CIAS score)	1.51 1.18–1.94	**.001**	1.91 1.45–2.51	**< .001**	1.81 1.40–2.35	**< .001**
Problematic videogame use (GASA score)	1.20 .97–1.49	.094	1.35 1.02–1.79	**.038**	1.24 .96–1.59	.097
Problematic social media use (SMDS score)	1.55 1.22–1.95	**< .001**	1.90 1.46–2.47	**< .001**	1.75 1.36–2.25	**< .001**

Note: CIAS = Chen Internet Addiction Scale, GASA = Game Addiction Scale for Adolescents, SMDS = Social Media Disorder Scale, OR = Odds Ratio. ORs with 95% confident intervals are shown. Crude ORs were adjusted for sex, age, residence (Krasnoyarsk, Abakan, Kyzyl), ethnicity (Russians, Khakass, Tuvans, Others), and Strengths and Difficulties Questionnaire total scale results ≥17.

confounding role of psychosocial problems in the associations found.

3.3.2. Multiple linear regression

The results of the regression analysis, which considered the relationship between the intensity of recurrent pain symptoms (as assessed using the Wong-Baker FACES Pain Rating Scale) and the severity of different types of PIU, are presented without (Table 5, Model 1) and with the inclusion of psychosocial problems according to the SDQ (Table 6, Model 2) as an important confounding variable. The results in Table 7 indicate that both models demonstrated significant positive relationships ($p < .001$), but the determination coefficient (R^2) for Model 2 was 42%–52% higher, indicating a stronger consistency of the model with the observed data.

When including psychosocial problems as a confounder (Model 2, Table 6), RH intensity was associated only with the presence of PSMU (β = .061; $sr^2 = .002$; $p < .001$). RAP intensity was associated with GPIU (β = .067; $sr^2 = .002$; $p < .001$) and PSMU (β = .064; $sr^2 = .001$; $p < .001$). RBP intensity was also associated with GPIU (β = .097; $sr^2 = .005$; $p < .000$) and PSMU (β = .043; $sr^2 = .001$; $p = .021$). However, the intensity of pain symptoms was not related to PVGU in any way.

3.3.3. Mediation analysis

Finally, the mediating role of psychosocial problems (assessed using the SDQ), was examined regarding the relationship between the severity of different types of PIU and the intensity of recurrent pain symptoms. The hypothesized relationships are shown in Fig. 1, with a summary of the analysis in Table 8. The results demonstrated a significant effect of PIU on the intensity of recurrent pain through indirect exposure to psychosocial problems, confirming H_3 (β = .012–.071; $p < .001$). Additionally, the direct impact of PIU on pain severity was also found to be significant (β = .007–.076; $p < .001$). Therefore, psychosocial problems partially mediated the association between PIU (which was presumably associated with excessive use of personal computers, tablets, and smartphones) and the intensity of pain episodes. However, these

Table 5
Linear regression analysis of the relationship between the intensity of recurrent pain symptoms and different types of problematic internet use. Model 1 (without SDQ results, N = 4411).

	Recurrent headache			Recurrent abdominal pain			Recurrent back pain		
	β	*p*	sr^2	β	*p*	sr^2	B	*p*	sr^2
Age	.021	.154	.004	.022	.127	.001	.029	**.048**	.001
Sex (female)	.243	**<.001**	.045	.230	**<.001**	.040	.148	**<.001**	.016
Generalized problematic internet use (CIAS score)	.104	**<.001**	.006	.139	**<.001**	.011	.164	**<.001**	.016
Problematic videogame use (GASA score)	.044	**.008**	.001	.030	.068	.001	.023	.178	<.001
Problematic social media use (SMDS score)	.094	**<.001**	.005	.095	**<.001**	.005	.073	**<.001**	.003

Note: CIAS = Chen Internet Addiction Scale, GASA = Game Addiction Scale for Adolescents, SMDS = Social Media Disorder Scale, β = standardized regression coefficient, sr^2 = squared semipartial correlation coefficient. Absolute values were used for age, dependency scales. Statistically significant ($p < .05$) coefficient values are written in bold.

Table 6
Linear regression analysis of the relationship between the intensity of recurrent pain symptoms and different types of problematic internet use. Model 2 (with SDQ results, N = 4411).

	Recurrent headache			Recurrent abdominal pain			Recurrent back pain		
	β	*p*	sr^2	β	*p*	sr^2	β	*p*	sr^2
Age	.028	**.047**	.001	.029	**.038**	.001	.035	**.013**	.001
Sex (female)	.204	**<.001**	.030	.192	**<.001**	.027	.112	**<.001**	.009
Strengths and Difficulties Questionnaire (SDQ score)	.260	**<.001**	.052	.251	**<.001**	.048	.235	**<.001**	.042
Generalized problematic internet use (CIAS score)	.029	.119	.001	.067	**.001**	.002	.097	**<.001**	.005
Problematic videogame use (GASA score)	.007	.402	<.001	−.005	.735	<.001	−.011	.520	<.001
Problematic social media use (SMDS score)	.061	**.001**	.002	.064	**.001**	.002	.043	**.021**	.001

Note: SDQ = Strengths and Difficulties Questionnaire, CIAS = Chen Internet Addiction Scale, GASA = Game Addiction Scale for Adolescents, SMDS = Social Media Disorder Scale, β = standardized regression coefficient, sr^2 = squared semi-partial correlation coefficient. Absolute values were used for age, dependency scales. Statistically significant ($p < .05$) coefficient values are written in bold.

Table 7
Comparison of linear regression models by coefficient of determination R^2, F-statistics and *p*-value.

Models	Recurrent headache			Recurrent abdominal pain			Recurrent back pain		
	R^2	F	*p*	R^2	F	*p*	R^2	F	*p* value
Model 1	.109	108.2	<.001	.118	118.2	<.001	.083	79.8	<.001
Model 2 (with SDQ score as confounder)	.162	141.8	<.001	.167	147.0	<.001	.126	105.6	<.001

Note: SDQ = Strengths and Difficulties Questionnaire, R^2 = coefficient of determination, F = regression model significance coefficient.

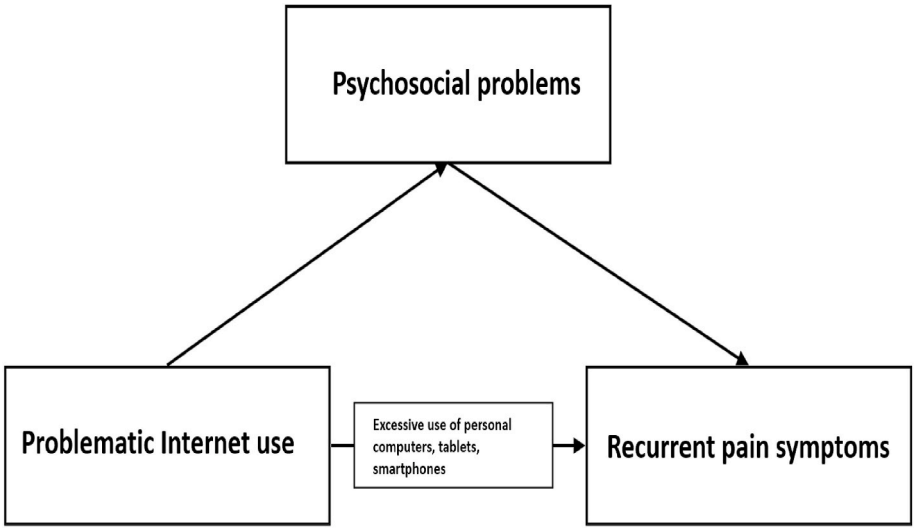

Fig. 1. The proposed mediation models.

findings are only applicable to GPIU and PSMU, but not to PVGU which exhibited no significant direct effects (PVGU- > psychosocial problems - > recurrent headache, $p = .056$; PGVU - > psychosocial problems - > recurrent abdominal pain, $p = .065$; PGVU - > psychosocial problems - > recurrent back pain, $p = .084$). Meanwhile, indirect effects were stronger for PSMU (.70 for RH, .76 for RAP, and .64 for RBP) than for GPIU (.12 for RH, .11 for RAP, and .10 for RBP). The results of the mediation analysis confirmed H_3 regarding the mediating role of psychosocial problems in the association between recurrent pain symptoms and different types of PIU, with varying direct and indirect effects across GPIU, PVGU, and PSMU.

4. Discussion

The present large-scale cross-sectional study found an association between different forms of PIU and recurrent pain symptoms (headache, abdominal pain and back pain) among adolescents. PIU was associated with an increased risk of recurrent pain symptoms among individuals in this age group (supporting H_1). Importantly, this association was most pronounced for GPIU and PSMU, whereas PVGU only showed a weak association with abdominal pain frequency. One of the key findings of the present study was that psychosocial problems played an important confounding role in the associations between PIU and recurrent pain symptoms (supporting H_2). In addition, mediation analyses showed that psychosocial problems partially mediated the association between GPIU, PSMU and pain episode intensity (supporting H_3). These findings suggest the need for a comprehensive approach to the treatment of adolescents with concurrent somatic pain and PIU, which should include not only optimizing adolescents' internet and digital device use but also addressing comorbid psychosocial problems.

Assessing recurrent pain symptoms necessitates evaluating not just their frequency but also their intensity, which must be significant enough to disrupt the adolescent's daily activities (King et al., 2011; Kolb et al., 2022; Perquin et al., 2000). The present study assessed associations of PIU with the frequency of recurrent pain symptoms, using multinomial logistic regression and considering sufficient numbers of

Table 8
Mediation analysis summary.

Relationship	Total Effect (*p*)	Direct Effect (*p*)	Indirect Effect	Confidence Interval		*t*-statistic	Conclusion
				Lower Bound	Upper Bound		
Generalized problematic internet use - > Psychosocial problems - > Recurrent headache	.019 (<.001)	.007 (<.001)	.012	.010	.013	12.15	Partial mediation
Problematic videogame use - > Psychosocial problems - > Recurrent headache	.022 (<.001)	.006 (.056)	.016	.014	.019	7.33	No direct effect
Problematic social media use - > Psychosocial problems - > Recurrent headache	.129 (<.001)	.059 (<.001)	.070	.060	.080	11.57	Partial mediation
Generalized problematic internet use - > Psychosocial problems - > Recurrent abdominal pain	.022 (<.001)	.011 (<.001)	.011	.010	.013	14.38	Partial mediation
Problematic videogame use - > Psychosocial problems - > Recurrent abdominal pain	.023 (<.001)	.006 (.065)	.017	.014	.020	7.33	No direct effect
Problematic social media use - > Psychosocial problems - > Recurrent abdominal pain	.147 (<.001)	.076 (<.001)	.071	.60	.082	12.91	Partial mediation
Generalized problematic internet use - > Psychosocial problems - > Recurrent back pain	.022 (<.001)	.012 (<.001)	.010	.008	.012	14.75	Partial Mediation
Problematic videogame use - > Psychosocial problems - > Recurrent back pain	.021 (<.001)	.005 (.084)	.016	.013	.018	6.91	No direct effect
Problematic social media use - > Psychosocial problems - > Recurrent back pain	.131 (<.001)	.067 (<.001)	.064	.055	.074	12.06	Partial mediation

Note: Sex and age were included as covariates in the models.

pain episodes according to the selected criteria (binary feature), and evaluated the impact of pain episode intensity – using multiple linear regression, when intensity was assessed using the Wong-Baker Visual/-Analogue Pain Rating Scale (categorical serial feature).

The multinomial logistic regression analysis, adjusted for gender, age and psychosocial problems showed an association of RH frequency with GPIU and PSMU, but not with PVGU (Table 4). Concurrently, RH intensity showed an association only with PSMU severity (Table 6). Therefore, when considering both pain frequency and intensity, only the association between RH and PSMU emerged as consistently significant. This finding aligns with findings from several other studies that have also identified an association between RH and PSMU (Al-Dubai et al., 2013; Deogade et al., 2017; Jha et al., 2016; Paakkari et al., 2021). The lack of a significant association between RH and other types of PIU (GPIU and PVGU) could be partially attributed to differences in preferred devices for accessing the internet. While PSMU is predominantly engaged through smartphones, the devices implicated in GPIU and PVGU are more varied, including desktop computers, consoles, and tablets. It is suggested that excessive smartphone use may be a key risk factor for RH among adolescents with PIU, a hypothesis that warrants further investigation.

Although the present survey did not distinguish between migraine and tension-type headache as manifestations of RH, the presence of a pronounced association of PSMU intensity with RH is suggestive of its predominantly migraine nature. This speculation finds some support in research conducted with Japanese and Brazilian student populations, which identified an association between PIU and headaches, particularly migraines (Bener et al., 2019; Corrêa Rangel et al., 2022; Ishii et al., 2020). Moreover, a study by Uttarwar et al. (2020) did not find any association between the frequency of smartphone use and the frequency of RH. However, it did report an association with pain severity, as indicated by increased medication use for pain management. This could suggest a higher intensity of pain, more characteristic of migraine than tension-type headache. The speculation assuming predominantly migraine headaches associated with active internet use necessitates further exploration, employing a differentiated approach to headache etiology and considering both the content consumed and the devices used (Langdon et al., 2024).

The mechanisms underpinning the relationship between PIU and headaches remain largely unexplored. A few potential explanations for the association between PSMU and headaches include:

Psychological tension and stress: Psychosocial problems associated with PSMU (Boer et al., 2020; Sserunkuuma et al., 2023) may be a cause of RH, which is further substantiated by their mediating role in the association of problematic social media use - > psychosocial problems - > recurrent headache (Table 8).

Hypodynamia: PSMU is associated lack of physical activity which is also associated with higher levels of stress and anxiety (Silva et al., 2020), muscle stiffness and tension, and poor brain circulation (Ferrer-Uris et al., 2022). Physical activity helps reduce stress and anxiety by releasing endorphins and other neurotransmitters such as serotonin and dopamine (Li et al., 2020). High stress levels without this outlet can increase the frequency and intensity of headaches. This is not surprising because dosed physical activity is a relatively effective therapy for both PIU and psychosomatic complaints (Li et al., 2020; Zhang et al., 2023).

Increased muscle tension: PSMU is often associated with extended periods spent using smartphones or in front of computer screens, contributing to a sedentary lifestyle (Hwang et al., 2022; Morningstar et al., 2023). This lifestyle can cause tension in the neck and shoulder muscles, leading to the development of 'text neck syndrome' (Tsantili et al., 2022), which may initiate or worsen headaches.

Vigilance and hypervigilance: The constant stimulation and alertness demanded by specific internet activities, such as social media browsing, reduces leisure time and can overwhelm the visual system, potentially causing fatigue and headaches.

Digital eye strain or computer vision syndrome: Adolescents who use the internet problematically often engage in prolonged screen time, causing their eyes to remain fixed on close objects and leading to additional strain. Symptoms can include headaches, eye fatigue, dryness, and blurred vision (Al-Marri et al., 2021; Mylona et al., 2020). This condition, stemming from muscular strain in the eyes, neck, and shoulders, can cause headaches, particularly in the forehead, temples, and occipital region (Pavel et al., 2022). Moreover, digital device use may alter blinking patterns, impacting ocular surface moisture and leading to dry eyes, thereby exacerbating headaches (Al-Marri et al., 2021).

Sleep disturbance: The habit of engaging in online activities or device use before sleep, a behavior commonly associated with PSMU, can disturb sleep patterns (Boniel-Nissim et al., 2023; Li et al., 2024; Tereshchenko et al., 2021). Poor sleep quality and quantity may lead to the development and increased severity of headaches.

Pain hypersensitivity: Hypersensitivity or heightened perception of pain may play a specific role in the pathogenesis of migraine and tension-type headaches (Fernández-de-las-Peñas et al., 2021; Schwedt,

2013). Hyperreactive perception of painful stimuli in persistent headaches may be a consequence of severe or repeated exposure to emotional stressors specific to PSMU.

The frequency and intensity of RAP in the present study were strongly associated with GPIU and PSMU but not with PVGU. Several common factors may explain this relationship, including reduced physical activity (Hwang et al., 2022; Morningstar et al., 2023; Viner et al., 2019), eating disorders (Hinojo-Lucena et al., 2019; Kożybska et al., 2021), irrational diet (Göbel et al., 2023; Kim et al., 2010), and obesity (Aghasi et al., 2020; Eliacik et al., 2016), all of which are reported among adolescents with PIU and contribute to digestive dysfunction (Cinquetti et al., 2021; Mei et al., 2022) and constipation (Çakar & Eren, 2023). Psychological stress and psychosocial problems associated with PIU may also contribute to the formation of visceral hypersensitivity and RAP, particularly in the context of irritable bowel syndrome (Tian et al., 2023).

In the present study, RBP was also associated with GPIU and PSMU, in terms of both pain frequency and intensity. PVGU showed no association with RBP. Possible causes of RBP formation in PIU are much the same as in the case of RH (see above). Spending prolonged hours in front of screens – be it computers, laptops, tablets, or smartphones – is a common trait among adolescents with PIU (Abir et al., 2021; Alsalameh et al., 2019; Ayhualem et al., 2021; İnal & Serel Arslan, 2021; Mustafaoglu et al., 2021; Özdil et al., 2022; Paakkari et al., 2021; Yang et al., 2019). This behavior often results in poor posture and improper body positioning, leading to increased strain on the neck and lower back. Adolescents engrossed in screen use frequently adopt hunched postures or hold devices in ways that place additional stress on neck and back muscles, contributing to the development of 'text neck syndrome' (Tsantili et al., 2022). Over time, as PIU intensifies, these poor postural habits can become ingrained, leading to chronic recurrent pain. The reported lack of sleep among adolescents experiencing PIU (Boniel-Nissim et al., 2023; Tereshchenko et al., 2021) and the habit of using digital devices while lying down, which is associated with dyssomnia, and can further compromise spinal and muscle health, potentially causing neck and lower back pain (Li et al., 2024). A lack of physical activity, often observed among individuals with PIU, exacerbates these issues. Furthermore, the role of psychological problems should not be underestimated; they can significantly magnify physiological risk factors, creating a vicious circle that intensifies the pain experienced.

Therefore, in line with the hypothesis, PIU was associated with recurrent pain symptoms among adolescents (H_1), with the pattern of these associations varying by the type of PIU – generalized PIU (GPIU), problematic game use (PVGU), and problematic social media use (PSMU) (H_2). Considering the frequency and intensity of pain, the present study found no significant association between PVGU and any of the pain symptoms addressed. Headaches were found to be associated solely with PSMU. Regarding abdominal pain and back pain, GPIU and PSMU demonstrated closely related association patterns. Previous research has identified two potential patterns of psychosocial problems in PIU: one common to both GPIU and PSMU, and another distinctly associated with PVGU (Tereshchenko et al., 2022). These results are strongly consistent with recent empirical research (Sánchez-Fernández et al., 2024; Wong et al., 2020). The findings of the present study reinforce this, particularly in relation to somatic symptoms.

The lack of conclusive association of recurrent pain symptoms with PVGU may be explained by the relatively lower severity of emotional spectrum disorders (depression, anxiety) and the different pattern of internet activity (less use of smartphones and tablets compared to PSMU). Furthermore, it is could be that gaming, especially with using virtual reality, may also have some therapeutic effect on pain symptoms, acting as a distraction (Eijlers et al., 2019; Pourmand et al., 2018).

Additionally, the role of psychosocial problems as a confounder in the association of PIU and recurrent pain symptoms was also confirmed (H_2). The outcomes from logistic and linear regression analyses indicated that the presence of psychosocial problems acted as confounder in the hypothesized relationship (i.e., PIU - > recurrent pain symptoms). By incorporating psychosocial problems into the logistic regression model, all association coefficients decreased by more than 10%. Similarly, their inclusion in the linear regression model led to a 42%–52% increase in the determination coefficient (R^2), signifying an improved model fit with the observed data.

H_3 was also confirmed. The mediation analysis results showed that psychosocial problems significantly mediated the association between PIU and the intensity of pain episodes. While direct effects were only found for GPIU and PSMU (but not for PVGU), the highest expression of indirect effects in the mediation models was reported for PSMU. However, the adopted statistical model only accounted for the unidirectional effect of PIU in the development of psychosocial issues and psychosomatic complaints. The precise nature of this interaction remains unclear. It is uncertain whether psychosocial problems are precursors to PIU or if they arise or worsen as a consequence of PIU. The possibility of a bidirectional influence or shared vulnerability has not been ruled out either. Recent longitudinal research demonstrated a two-way relationship between PIU and depression, suggesting a common vulnerability (Yang et al., 2022). A longitudinal study by Chang et al. (2022) also demonstrated a bidirectional association between anxiety and PSMU, whereas for PVGU, the impact of problematic gaming on the development of new anxiety symptoms appeared to be unidirectional.

In the present study it was predominantly hypothesized that there would be a unidirectional effect of PIU on the onset or worsening of somatic symptoms (PIU - > recurrent somatic symptoms). However, the cross-sectional design of the study did not allow for a determination of the direction of this relationship, which may be inverse (recurrent pain symptoms - > PIU) or bidirectional (PIU <–> recurrent pain symptoms). In fact, inverse (or bidirectional) directionality (recurrent somatic symptoms - > PIU) is quite likely because (i) individuals with chronic somatic health conditions frequently encounter restrictions in their daily lives, which can result in social isolation. Playing videogames and using social media can serve as a means of compensating for deficiencies in socialization and activity; (ii) the presence of chronic somatic symptoms (such as recurrent pain) and the constant stress associated with illness can encourage individuals to seek out distractions. Playing videogames and using social media can provide a transient respite from these challenges, which may precipitate the development of problematic behaviors; (iii) individuals with chronic somatic symptoms may also experience depression and anxiety. This can serve to increase the likelihood of developing PIU. In this instance, psychosocial issues may also function as a mediator, operating in the inverse direction of the relationship (recurrent somatic symptoms - > psychosocial problems - > PIU); and (iv) adolescents with chronic somatic health conditions may be more likely to engage in internet use, play videogames and/or use social media as a coping strategy to manage physical and emotional stress, which may contribute to PIU.

The data on the prevalence of PIU among patients with chronic somatic complaints is extremely limited and inconsistent. For instance, research indicates that adolescents with chronic somatic health conditions do not spend excessive screen time or play videogames more intensively than healthy peers (Alexandridis et al., 2023; Berkelbach van der Sprenkel, 2022; Cury et al., 2022). The prevalence of PIU has been reported to be lower among children with type 1 diabetes mellitus when compared to controls (Büyükyılmaz et al., 2023). However, a higher risk of PIU has been reported among individuals with atopic dermatitis, chronic urticaria, psoriasis, asthma, and obesity (Bozkurt et al., 2018; Han et al., 2021; Pilz et al., 2022; Schielein, M., 2021).

As far as the present authors are aware, there are no longitudinal or experimental studies that have clarified the direction of such relationships in the context of recurrent pain symptoms. Recent reviews also highlight the lack of prospective studies on the relationship between excessive internet use and health-related quality of life, as well as headache and musculoskeletal complaints (Langdon et al., 2024;

Masaeli & Billieux, 2022; Zirek et al., 2020). The cross-sectional design of the present study did not allow the determination of the direction of the association between different types of PIU and pain symptoms, only their associations. The worldwide lack of prospective data in this research area underlines the need for such studies.

4.1. Strengths, limitations, and future directions

The strengths of the present study include its large-scale school-based sampling. It also simultaneously examined three types of problematic online behavior, investigated three recurrent pain symptoms, and assessed pain episodes by their frequency and intensity. The study also considered the role of psychosocial problems as both confounders and mediators, with the aim of providing a more comprehensive understanding of the mechanisms associating PIU and recurrent pain in adolescents.

The limitations of the present study primarily stem from its cross-sectional design and reliance on self-reported measures for PIU and somatic symptoms. The lack of a longitudinal framework restricts the ability to adequately assess causality and the persistence of symptoms over time. The present study hypothesized a unidirectional effect of PIU on somatic symptoms, but the direction of this relationship could not be confirmed due to the cross-sectional study design. The associations could be inverse or bidirectional, because chronic conditions, such as recurrent pain symptoms with pronounced frequency and intensity, may lead to increased internet use for coping and socialization. Longitudinal and experimental studies are therefore needed to clarify the direction of these relationships because the current data are limited and inconsistent.

The potential confounding variables of future studies may also include existing somatic health problems (e.g., being overweight, vision problems, atopic diseases), mental health disorders (e.g., phobic disorders, obsessive-compulsive disorder, anxiety, depression), personality traits (e.g., extraversion or introversion), family socioeconomic status and parental education, family and peer conflicts/support, educational load, lifestyle factors (diet, physical activity, sleep, smoking, energy drinks, alcohol). Studies of cross-cultural differences are also needed.

Retrospective self-reporting may also introduce biases related to social desirability, consent, and memory recall, which are common in psychological studies utilizing self-administered surveys (Latkin et al., 2017; Vesely & Klöckner, 2020). Further research is necessary to elucidate the relationship between PIU and somatic complaints, especially considering psychosocial/psychiatric issues, and should include longitudinal and experimental studies. In addition, the study was limited to an adolescent sample, and the results may be different among adults (and especially older adults).

An additional limitation is the study's failure to record levels of physical activity and sleep pattern. Moreover, the survey did not account for the types of devices used (desktop computers, laptops, smartphones, tablets, etc.), related technologies, or specific characteristics of games and social media platforms. Future research should employ more objective methods, such as longitudinal and experimental designs with precise measurement of online time, considering type of devices accessed, type of content consumed, and types of technology employed. It should also involve the use of daily 'pain diaries' to track any association with the intensity of internet use more accurately. Documenting low levels of physical activity and sleep deprivation as risk factors for recurrent pain symptoms and common comorbidities of PIU is crucial. Ideally, future research could utilize a program voluntarily installed on computers, tablets, and smartphones to record all aforementioned parameters of internet use, along with disturbances in physical activity and sleep patterns. This would also facilitate the long-term tracking of emerging symptoms.

5. Conclusion

The present study conducted a large-scale investigation into the relationship between PIU and recurrent pain symptoms among adolescents. The findings corroborated the association between PIU and the prevalence of recurrent pain symptoms among adolescents. Notably, this association was partially mediated by psychosocial problems, underscoring the significance of psychological health in this context. Support from parents, engagement in physical activities, regularization of sleep patterns, and application of various behavioral therapies could help adolescents in addressing psychological issues, reducing PIU, and diminishing the risk of associated recurrent pain.

Another critical observation is the complex relationship between different types of PIU and recurrent pain symptoms. The differences found between GPIU, PVGU, and PSMU in their associations with pain symptoms underscore the necessity of considering the type of online activity used to analyze and interpret study outcomes. These variances might also hint at unique interaction mechanisms for each category of PIU, necessitating further research employing more refined methods to evaluate the content accessed, the devices used, and patterns of internet activity.

CRediT authorship contribution statement

Sergey Tereshchenko: Writing – original draft, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Edward Kasparov:** Methodology, Funding acquisition, Conceptualization. **Valery Manchuk:** Methodology, Conceptualization. **Lidia Evert:** Investigation. **Olga Zaitseva:** Investigation. **Marina Smolnikova:** Investigation. **Margarita Shubina:** Investigation, Data curation. **Nina Gorbacheva:** Investigation, Data curation. **Ivan Novitckii:** Investigation. **Olga Moskalenko:** Investigation. **Ludmila Lapteva:** Investigation. **Mark D. Griffiths:** Writing – review & editing, Conceptualization.

Informed consent

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all participants for being included in the study.

Ethical approval

The study was approved by the Ethics Committee of the Federal Research Center (Krasnoyarsk Science Center of the Siberian Branch of the Russian Academy of Sciences) and adhered to the tenets of the Helsinki Declaration (Internal code: 12–2018; Date of approval: December 10, 2018).

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Declaration of competing interest

ST, EK, VM, LE, OZ, MSm, MSh, NG, IN, OM, and LL declare that they have no conflict of interest. MDG has received research funding from *Norsk Tipping* (the gambling operator owned by the Norwegian government). MDG has received funding for a number of research projects in the area of gambling education for young people, social responsibility in gambling and gambling treatment from *Gamble Aware* (formerly the

Responsibility in Gambling Trust), a charitable body which funds its research program based on donations from the gambling industry. MDG undertakes consultancy for various gambling companies in the area of player protection and social responsibility in gambling.

Data availability

Data available at https://doi.org/10.5061/dryad.1g1jwsv4z.

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