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Systematic Review

Associations between smartphone use and mental disorders in college students: a systematic review

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ABSTRACT

Smartphones are now ubiquitous in the daily lives of undergraduate students, but their excessive use may be related to psychological problems and to the development of mental disorders. To verify the influence of smartphone use on the development of mental disorders in university students, a systematic review of the literature was conducted, according to preferred reporting items for systematic reviews and meta-analysis (PRISMA) and registered in PROSPERO under number CRD42023401060. The search was carried out in June 2024 with the descriptors: "smartphone", "university students", "college students" and "mental disorders", in the PubMed, PsycInfo and Scopus databases. Of the 48 studies included, most found associations between excessive use of smartphones and the presence of mental disorders in university students. Only two articles observed improvement in anxiety, depression and stress associated with smartphone use and one study found no associations. Depression, anxiety, and stress were the main mental disorders found among university students. The excessive use of smartphones is associated with the presence of psychological problems in university students. Constant smartphone availability and online studies favours the development of psychopathologies in university students. The findings in this review strengthen the evidence of the need to develop strategies to live in a healthy way with the digital world.

Keywords: College students, Media, Mental disorders, Smartphone, University students

INTRODUCTION

Technological advances have expanded the use of cell phones, which have become a daily necessity for most undergraduate students.[1,2] The rise of Android as the dominant operating system in 2012 solidified the formation of consumer preference in the smartphone market.[3] In the same year, the proportion of Americans who owned smartphones exceeded 50%, leading to a drastic change in social behavior, especially among generation Y and post-generation Y.[4] In addition to academic needs, negative real-life situations can be alleviated through internet content, which increases smartphone use.[5,6]

The condition of problematic smartphone use (PSU) refers to excessive use of or smartphones addictions (SA), and resembles substance use disorder, affecting users' daily lives.[7] Excessive smartphone use, especially for activities such as gaming, texting and social interaction, has been associated with negative physical and mental health outcomes in young people.[8] University students show a pattern of smartphone use associated with academic demands, and this intensive use for academic purposes can mask or justify behaviors that, in other circumstances, would be considered excessive. In a recent study, more than half of university students reported checking their devices between 1 and 10 times per hour, which seems like a high frequency of interruptions in a study context.[9]

Excessive smartphone use is closely related to many psychological and behavioral disorders.[10] Among university students, anxiety, depression, stress, and poor sleep quality have been reported.[11,12] A recent review concluded that smartphone addiction has been associated with sleep disturbances, academic performance, procrastination, impulsivity, self-esteem, reduced social interaction, loneliness and suicide. However, the research was restricted to Korean university students.[13] Other reviews along these lines have focused on the relationship with physical activity levels[14] or restricted the study population.[15] Therefore, this review aims to survey and discuss the associations between smartphone use and psychopathological outcomes in university students. Emphasis is placed on different purposes of smartphone use, not just problematic or addictive use, and the possible influence on mental conditions of university students.

METHODS

This review was conducted in accordance with the PRISMA and registered with PROSPERO under the number CRD42023401060. A search was carried out in June 2024 around the following question: What is the impact of excessive smartphone use on the mental health of university students? To do this, the following descriptors were cross-referenced: "smartphone", "university students", "college students" and "mental disorders", combined with the AND operator, in the PubMed, PsycINFO and Scopus databases. University students formed the study population. Exposure was represented by smartphone use, and outcomes by the mental disorders addressed in the articles. Inclusion criteria: (1) studies carried out in a population of university students, (2) published from 2012 onwards, (3) articles that directly assessed associations between smartphone use (use in general, for fun, work, study, communication and not just use already classified as problematic or dependent on the device) and mental disorders; (4) studies that used validated screening instruments. Exclusion criteria: (1) population previously diagnosed with mental disorders; (2) smartphones used as an aid to functionality or treatment of mental disorders. Initially, independent preliminary searches were conducted. The screening of articles from the main search was carried out in pairs. Figure 1 shows the article selection process in detail.

Quality assessment

The Cochrane collaboration's risk of bias tool was used to assess the risk of bias of randomized clinical trials.[16] The Newcastle Ottawa scale was used to check the methodological quality of observational studies.[17] The evaluation was carried out in pairs and discrepancies were resolved by consensus with a third reviewer. The maximum score (9 points) represents high methodological quality for observational studies.[18]

The database searches totaled 4,739 articles. After excluding 1,199 duplicates, 3,540 articles were assessed by title and abstract. One hundred and twenty-one articles were read in full and 48 studies were included in this review. Figure 1 details the article selection process in the PRISMA Flowchart.

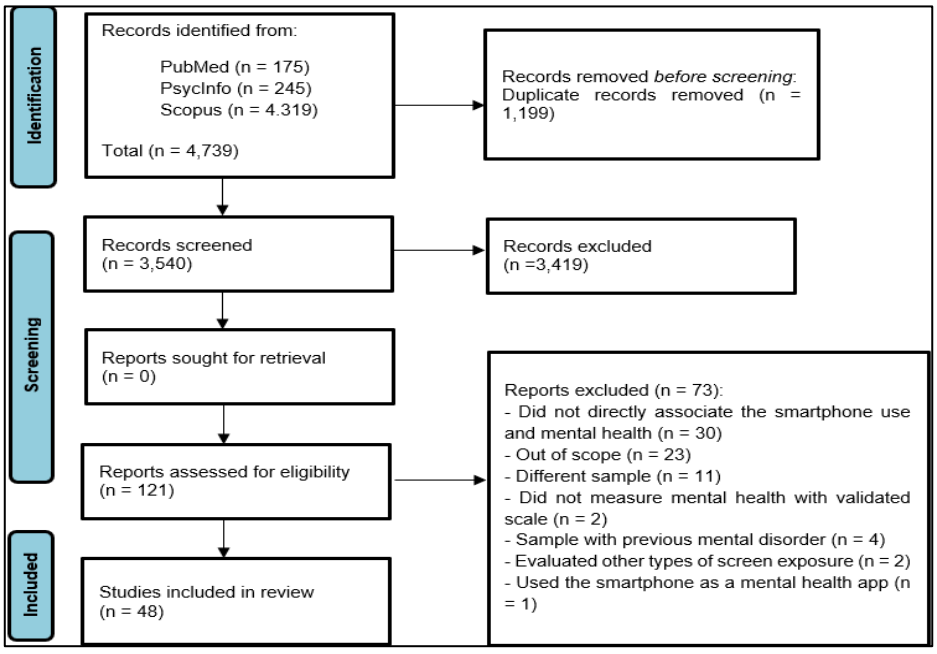

Figure 1: PRISMA flowchart.

Sample characteristics

Of 48 studies included in this review, 41 cross-sectional, 6 were longitudinal and 1 was a randomized clinical trial. Studies came from 21 countries, totaling 55,814 university students with a predominance of females and a mean age of 20.75 years (SD=3.67). Table 1 provides a summary of characteristics of all articles included in this review.

Table 1: Description of the associations of the included studies.

Country, type of study and reference	N/ age (in years)/ gender	Mental health-assessment	Main associations	Quality score
Jordan, cross-sectional[19]	n=2337 Age=18 to 30+ 87.2% females	Mental health: Kessler psychological distress scale (K10)	Smartphone use negatively affected women's sleep and ability to fall asleep, making them more prone to smartphone addiction, especially when they are more tired and when they avoid activities that require effort (p<0.05). In contrast, men aged 30 or over, married and with higher education were less likely to develop smartphone addiction (p<0.05). Small effect size.	***
Turkey, cross-sectional[20]	n=494, Mean age: 20.22 75.9% female	Somatic symptoms, anxiety and insomnia, social dysfunction, and depression (GHQ-28)	Positive correlations between smartphone addiction and somatic symptoms (r=0.13), anxiety and insomnia (r=0.26), and depression (r=0.28). Small effect size.	***
Oman, cross-sectional[21]	n=404 Mean age: 21.5 64% females	Depression, anxiety, and stress: depression anxiety and stress scale (DASS) Insomnia: insomnia severity index (ISI)	Positive correlation between smartphone uses and insomnia (rs=0.618, p<0.05); anxiety (rs=0.492, p<0.05); and stress (rs=0.506, p<0.05).	***
Iran, cross-sectional[22]	n=1,400 Mean age: 25.17 68.2% females	Psychological disorders (personality disorder; mood disorder): Millon clinical multiaxial inventory (MCMI-III) Mental disorder: interview for DSM-IV disorders Impulse control disorder (ICD): interview based on DSM-IV criteria	Dependent personality disorder was 3.1 times more likely to increase the likelihood of mobile dependence, compulsive personality disorder increased the chance of smartphone dependence (OR=3.2), with medium effect size. Bipolar spectrum disorders and depressive disorders increased the risk of smartphone addiction by 4.2 times.	***
Nigeria, cross-sectional[23]	n=398 Mean age: 21.75 100% females	Depression: patient health questionnaire (PHQ-9) Anxiety: generalized anxiety disorder scale (GAD-7)	1.01% of respondents were likely to be addicted to smartphones and 17.34% were at risk. Addicted/ at-risk smartphone users scored higher on depression and anxiety symptoms than normal smartphone users (p<0.05). small effect size.	***
Canada, longitudinal[24]	n=187 Mean age: 20.1 80.9% females	Stress: daily inventory of stressful events (DISE) and 4-point Likert scale Mood: adaptation of positive and negative affect schedule-short.	Average daily smartphone hours have association with irritable mood b(SE)=0.120 (0.028) and stressed mood b(SE)=0.086 (0.028). Small effect size.	***
USA, randomized controlled trials (RCT)[25]	n=163 Mean age: 24.4 51% female	Anxiety: state-trait anxiety inventory (STAI)	Participants who used the phone for more hours per day showed a strong increase in anxiety over time, (p<0,001). Moderate daily users, there was a significant change in anxiety over time (p=0.04). For low phone use users, there were no significant differences in anxiety over time (p=0,91). Large effect sizes.	U
Peru, cross-sectional[26]	n=3139 Mean age: 22 61.1% females	Anxiety and depression: Hopkins symptom checklist-25 (HSCL-25), a shortened version of the HSCL-58 scale.	The nomophobia score was higher in students with possible anxiety (β: 6.6, 4.3 to 8.9) and depressive (β: 19.5, 5.2 to 9.6) symptomatology. Large effect sizes.	***
Pakistan, cross-sectional[27]	n=400 Mean age: 24.45 45% females	Depressive symptoms: PHQ-9, mood disorder: mood disorder questionnaire (MDQ)	Positive associations between cell phone use and depression (r=0.430) p=0.000 and mood disorders (r=0.608) p=0.000). Medium effect sizes.	***
Turkey, cross-sectional[28]	n=319 Mean age: 20.5 63.63% female	Sleep quality: Pittsburgh sleep quality index (PSQI) Depression: Beck depression inventory (BDI) Anxiety: Beck anxiety inventory (BAI)	Depression, anxiety, and the daytime dysfunction component of the PSQI were higher in the high smartphone use group than in the low smartphone use group (p=0.001, p<0.001, p=0.0011, respectively). The severity of smartphone use was positively correlated with depression (r=0.267/ p<0.001), anxiety (r=0.276/ p<0.001) and global PSQI scores (r=0.156 / p=0.014), with small effect sizes.	***

Continued.

Country, type of study and reference	N/ age (in years)/ gender	Mental health-assessment	Main associations	Quality score
China, cross-sectional[29]	n=553 Mean age: 19.83 60.2% females	Anxiety: GAD-7	Positive correlation of mobile phone addiction with anxiety (r=0.40, p<0.01). Medium effect size.	***
China, cross-sectional[30]	n=850 Mean age: 19.04 68.1% females	Sleep quality: PSQI Depressive symptoms: symptom checklist-90 (SCL-90)	Positive correlation of mobile phone addiction with depressive symptoms (r=0.47, p<0.01) and neurotic personality (0.34, p<0.01). Medium effect size.	***
China, cross-Sectional[31]	n=1034 Mean age: 19.34 65,3% females	Anxiety and depression stress scale-21 (DASS-21) fear of missing out scale (FOMO)	Positive correlation of depression with SUF (p=0.004). FOMO was positively related to frequency of smartphone use and PSU severity.	***
USA, cross-sectional[32]	n=68 Mean age: 19.75 64.7% females	Symptoms of major depressive episode, PHQ-9), emotion regulation questionnaire (ERQ)	Greater severity of baseline depression was associated with decreased smartphone use throughout the week (p<0.05). Greater use of expressive suppression as an emotion regulation strategy predicted more baseline smartphone use, but less smartphone uses during the week.	***
Tunisia, cross-sectional[33]	n=700 Mean age: 21.5 67.6% females	The depression, anxiety and stress scales (DASS-21) schizotypal personality questionnaire (SPQ)	Higher smartphone, internet, and Facebook addiction scores were positively correlated with each of the depression, anxiety, and stress subscores; and depression (r=0.474), anxiety (r=0.499) and stress (r=0.461) scores were positively correlated with higher schizotypal traits. Medium effect size.	***
China, cross-sectional[34]	n=421 Mean age: 19.29 68.9% females	Anxiety: STAI-T Depression: center for epidemiological studies depression scale (CES-D)	Positive correlation of smartphone addiction with anxiety (r=0.36; p<0.01) and depression (r=0.41; p<0.01). Medium effect size.	***
Egypt, Oman and Pakistan, cross-sectional[35]	n=2616 Mean age: 22.5 73.05% females	Rates alexithymia: Toronto Alexithymia scale (TAS-20) DASS-21	Hours of smartphone use have a significant positive correlation with alexithymia (R^2=0.01; p<0.010). Small effect size.	***
Poland, cross-sectional[36]	n=402 Mean age: 20 74.1% females	Depression: Center for epidemiologic studies depression scale Measurement of phubbing: Phubbing scale	Cell phone addiction was positively associated with communication disorders (r=0.49, p<0.001) and telephone obsession (r=0.47, p<0.001). Communication disorders caused by telephone use (r=0.21, p<0.01) and telephone obsession (r=0.18, p<0.01) associated with higher levels of depression. Medium effect sizes.	***
Turkey, cross-sectional[37]	n=437 Age: 19 to 29 73.45% females	Anorexia and bulimia nervosa: eating attitudes test (EAT-40)	Duration of using smartphones was higher in students being at risk of eating disorders (p<0.05). Students being at risk of eating disorders had significantly higher prevalence of potential internet addiction than others (36.4% and 9.7%, respectively). Medium effect size.	***
Turkey, cross-sectional[38]	n=804 Mean age: 20,93 65% females	Sleep quality: PSQI Depression: BDI	Positive associations between smartphone addiction and daily smartphone use (β=0.531; p<0.01); use of social media (β: 0.124; p<0.01); play (β: .083; p<.05); PSQI score (β: 0.099; p<0.01); and point on the BDI (B=0.194; p<0.01). Small effect sizes.	***
China, cross-sectional[39]	n=412 Mean age: 20.71 63.6% females	Depression: BDI Anxiety: BAI Psychological inflexibility (AAQ-II)	SPAS-SV scores were positively associated with AAQ-II (r=0.265, p<0.001), BDI (r=0.254, p<0.001) and BAI (r=0.250, P<0.001) scores. AAQ-II was positively associated with BDI and BAI scores (r=0.550, p<0.001 and r=0.446, p<0.001), respectively. Small effect sizes.	***

Continued.

Country, type of study and reference	N/ age (in years)/ gender	Mental health-assessment	Main associations	Quality score
China, cross-sectional[40]	n=973 Mean age: 19 50.9% females	Depression: PHQ-9 Sleep disturbances: PSQI	Positive association between cell phone addiction and sleep disorders R2=0.43. Significant positive correlation between cell phone addiction and depressive symptoms R2=0.41. Large effect sizes.	***
China, cross-sectional[41]	n=1062 Mean age: 20.65 53.86% females	Depression: Zung self-rating depression scale (SDS) Anxiety: Zung self-rating anxiety scale (SAS) Stress: perceived stress scale (PSS) Perfectionism: Chinese frost multidimensional perfectionism scale (CFMPS)	Depression, anxiety, and stress were positively associated with PSU (P<0.001). Emotional symptoms (SAS + SDS) OR 1.04 CI 1.03-1.05 (p=0.039) and stress (PSS) OR 1.14 CI 1.10-1.17 (p=0.003), positively associated with PSU. Small effect sizes.	***
India, cross-sectional[42]	n=204 Mean age: 20 27.9% females	Depression: PHQ-9	Positive correlation of smartphone addiction with depression scores (p=0.23, p=0.001, R^2=0.045). Small effect size.	***
Lebanon, cross-sectional[43]	n=688 Mean age: 20.64 47% females	Brief depression and anxiety trackers (PHQ-2 and (GAD-2)	Higher total SPAI score was associated with higher depression score, (β=0.201, p=0.000) and anxiety (β= 0.122, p=0.034), with small effect sizes.	***
Serbia, cross-sectional[44]	n=761 Mean age: 21.81 31.5% females	Depression, anxiety and stress: DASS-21, Sleep quality: PSQI Physical activity: physical activity questionnaire-short form (IPAQ-SF)	Smartphone addiction increased stress [OR=1.75 (1.21-2.52), p=0.003], anxiety [OR=2.04 (1.44-2.90), p<0.001] and depression [OR=2.29 (1.59-3.29), p<0.001]. Small effect size.	***
USA, cross-sectional[45]	n=431 Mean age: 21,2 64.5% females	Depression: center for epidemiological study short depression scale (CES-D10) Anxiety: general anxiety disorder-7 (GAD-7) TDAH: Adult ADHD self-report scale (ASRS-v1.1) Insomnia: ISI	Total screen time was positively associated with having symptoms of 2 or more mental illnesses (OR [95% CI]=4.08 [2.40, 6.97]), with 4 times greater odds of experiencing comorbid mental illnesses for each 1 hour increase in screen time. Medium effect size	***
Nigeria, cross-sectional[46]	n=3328 Mean age: 21.3 55.2% females	Psychological distress: general health questionnaire (GHQ-12)	Problematic smartphone usage is positively associated with psychological distress [B=0.461, OR=1.586 (1.258-2), p<0.001). Small effect size.	***
USA, cross-sectional[47]	n=426 Age: 18 to 24+ 65% females	Depressive symptoms: center for epidemiological scale-depression (CES-D)	Those with more than 5.72 hours of mobile screen time were significantly more likely to have depressive symptoms (OR 3.49 95% CI 1.24-9.86), with medium effect size.	***
Japan, longitudinal[48]	n=25 Mean age: 20.45 100% females	Anxiety inventory state-trait (STAI) Profile of mood states (POMS)	Significantly higher state-anxiety score (p=0.0400, d=0.909) and trait-anxiety score (p=0.0072, d=1.231) in long-term users. Significantly lower trait anxiety scores (p=0.0351, d=0.257) for short-term use compared to long-term use. Large effect size.	***
Peru, cross-sectional[49]	n=370 Mean age: 20 61.9% Females	Depression: PHQ-9 Anxiety: GAD-7	The presence of depressive symptoms was moderately associated with addictive smartphone use p<0.001. The presence of anxiety symptoms was strongly associated with addictive smartphone use p<0.001. Medium effect size.	***
Canada, cross-sectional[50]	n=152 Age: 18 to 24 77% females	Adult STAI Addiction-Prone personality scale (AP)	Problematic cell phone use (MPU) did not significantly predict state anxiety in any of the three experimental conditions: β= −0.010, p=0.842 for the "withdrawal" condition; β=−0.025, p=0.606 for the "Protruding" condition; and β=−0.045, p=0.509 for the "hidden" condition. Small effect sizes.	***

Continued.

Country, type of study and reference	N/ age (in years)/ gender	Mental health-assessment	Main associations	Quality score
Canada, cross-sectional[51]	n=204 Mean age: 20,6 84.2% females	DASS-21 Difficulties in emotion regulation scale-18 (DERS-18)	Positive associations between psychological distress and PSU (p<0.001); between psychological distress and emotion dysregulation (p<0,001). Small-to-moderate effect sizes.	***
China, cross-sectional[52]	n=800 Mean age: 19.06 (1.35) 60.1% females	Ostracism: Ostracism experience scale for adolescents (OES-A) Social self-efficacy: Scale of perceived social self-efficacy (PSSE) Rejection sensitivity: tendency to expert rejection scale	The PSU has a positive correlation with Ostracism (r=0.286) and rejection sensitivity (r=0.346). Small and medium effect sizes. Additionally, the PSU has negatively correlated with social self-efficacy (r=-0.238). Small effect size.	***
China, cross-sectional[53]	n=4624 Mean age: 19.91 55.49% females	Depression: PHQ-9 Sleep quality: PSQI	The PMPU group exhibited higher PSQI and PHQ-9 scores (Cohen's d=0.819, p<0.001, and Cohen's d=1.164, p<0.001, respectively). Large effect sizes. Sleep problems (OR=1.48, 95% CI=1.43∼1.53) and the PMPU (OR=1.11, 95% CI=1.10∼1.12) increased the risk of depressive symptoms.	***
Singapore, cross-sectional[54]	n=53 Age=21 to 30 Gender: NP	Depression: PHQ-9 Anxiety: Anxiety disorder scale (GAD-7) Stress: PSS	Positive correlation of PSU with depression (r=0.66, p<0.001), anxiety (r=0.42, p<0.001) and stress (r=0.0.50, p<0.001). Respectively: Large, medium and large effect sizes.	***
USA, cross-sectional[55]	n=140 Mean age: 26,4 47.86% females	Anxiety: Liebowitz social anxiety scale (LSAS)	Strong positive association between PSU and social anxiety (r=0.562; p<0.01). Moderate positive association between PSU and LSAS social fear subscale (r=0.569; p<0.01). And moderate positive association between PSU and social behavior on the LSAS avoidance subscale (r=0.537; p<0.01). Large effect size.	***
Italy and Serbia, cross-sectional[56]	n=785 Mean age: 20.75 67.8% females	DASS-21	Male students present symptoms of depression 1.57 times more frequently (OR=1.57). Symptoms of depression are more common in those students who make fewer calls during the day (OR=0.7), send more SMS (OR=1.31) and surf the internet less on their cell phone (OR= 0.85). Stress is more common in students who make fewer calls per day (OR=0.79), those who spend more time talking on the cell phone per day (OR=1.28), younger students (OR=0.8), and those who play less frequently (OR=0.83). High levels of stress, the strongest predictor was keeping the cell phone less than 1 m away during sleep (OR=1.48). Small effect size.	***
USA, cross-sectional[57]	n=150 Mean age: 19.28 83.2% females	Social stress: Outcome questionnaire-45.2 (OQ-45.2) Sleep quality: PSQI	Sleep duration was positively related to dependence on smartphone use (p<0.05). Socio-emotional distress, distress symptoms, interpersonal relationships, social role were positively affected by smartphone addiction (p<0.01).	***
Malaysia, cross-sectional[58]	n=525 Mean age: 22 33.1% females	Depression, anxiety and stress: DASS suicidal behavior (SBQ-R)	Smartphone addiction has significant positive correlations with depression, anxiety, stress, and suicidal tendencies (p<0.001). Large effect size.	***

Continued.

Country, type of study and reference	N/ age (in years)/ gender	Mental health-assessment	Main associations	Quality score
China, longitudinal[59]	n=7434 Age: 19,67 years 48.2% females	Depression: PHQ-2 Anxiety: social anxiety disorders (SAD)	PSU was significantly correlated with possible SAD, depressive symptoms, loneliness, family conflict, and academic stress (all p<0.001). Students with possible SAD (AOR=2.45) and depressive symptoms (AOR=1.59) had a higher risk of PSU. Medium effect size.	***
China, cross-sectional[60]	n=9716 Age: 29.7 43.6% females	Anxiety: GAD-7	Positive association between duration of smartphone use and anxiety p<0.001. Small effect size.	**
China, cross-sectional[61]	n=475 Mean age: 19.77 44% females	Academic emotions questionnaire (AEQ), self-regulation scale (SRS), life satisfaction scale (SWLS)	PSU was positively associated with academic anxiety (r =0.28, p<0.01) and life satisfaction (r =−0.16, p < 0.01), with small effect size, and negatively with self-regulation (r−0.35 p<0.01), with medium effect size. PSU was negatively predicted by autoregulation (β=−0.35, p<0.001), with medium effect size. PSU positively predicted academic anxiety (β =0.18, p<0.001), with small effect size.	***
China, longitudinal[62]	n=1186 Mean age: 18.08 52.3% females	Sleep disorders: PSQI	There were small to moderate positive associations between PSU and SD at baseline and follow-up (r ranges from 0.149 to 0.321, all p<0.001. Medium size effect.	***
China, cross-sectional[63]	n=1629 Mean age: 23.85 65% females	Depressive symptoms: 9-item PHQ-9 GAD-7	Individuals with PSU were more likely to report depressive (OR=3.14), anxiety (OR=3.73) and insomnia (OR=2.96) symptoms than those without PSU, with average effect sizes. The associations of PSU with depressive (OR=4.66 vs. 2.33, p=0.015) and anxiety (OR=6.05 vs. 2.94, p=0.021) symptoms were more pronounced in the online learning group, with large effect sizes.	***
China, cross-sectional[64]	n=1,123 Age: grade 62.6% females	Stress: PSS	Perceived Stress was positively associated with mobile phone addiction (β=0.211, p<0.001), with small effect size.	***
USA, longitudinal[65]	n=222 Mean age: 19,6 60% females	Psychological stress: 10-item version of the PSS Depression: 10-item center for epidemiologic studies depression scale	Increased stress significantly predicted increased person-to-person smartphone use. Increased social support was associated with more cell phone use. The interaction of perceived stress and social support was not significant. The association between PSU and depression was mediated by stress (b=0.26, 95% CI [0.15, 0.37]). Medium effect size.	***
China, longitudinal[66]	n=1423 80.6% females Mean age: Grade	Sleep procrastination: sleep procrastination scale Sleep biorhythms: Morningness-eveningness questionnaire	PSU in time 1 has a positive relation with sleep procrastination time (r=0.57) and time 2 (r=0.35). PSU in time 2 has positive relation with sleep procrastination in time 1 (r=0.34) and time 2 (r=0.67). All results with p<0.001 and, respectively, large, medium, medium and large effect sizes.	***

***high quality studies; **moderate evidence; U: unclear; NP: not provided; SD: standard deviation; OR: Odds ratios; CI: confidence interval

Quality assessment of the included studies

Of the 47 observational studies, 40 were of high quality according to the Newcastle Ottawa Scale scores, especially due to the higher scores in the sample selection criteria. In the randomized clinical trial evaluated, the data provided was not sufficient for a high-quality classification of the study. A classification of the methodological quality of each study is presented in the last column of Table 1.

Associations between smartphone use and mental disorders

Among the 48 articles selected, only one found no association between smartphone use and mental health problems in university students. An improvement in anxiety, depression and stress associated with smartphone use was observed in two articles observed improvement. In the other 45 studies, smartphone use was associated with worse mental health in university students. When compared to regular smartphone use, PSU or AS were associated with greater manifestation of depressive symptoms (n=13), anxiety (n=14), and stress (n=6) in university students.

The use of smartphones for any activity, for periods between 5.72-12.07 hours, was associated with higher odds of depressive symptoms compared to use for less than 3 hours a day (n=1). Hours of daily use are positively associated with the severity of symptoms of depression, anxiety and stress (n=2). One study found that texting and playing games on the smartphone for long periods of time and staying close to the phone during sleep was associated with symptoms of depression and stress. In two other studies, the nomophobia score was higher in students with anxiety, depressive symptoms and stress.

Here, negative associations were also found between smartphone use and depression. Depression was less severe when students increased their weekly smartphone use time for video and voice calls, text messaging, internet browsing, gaming, social networking, taking photos or videos, watching TV, videos, and movies, reading books or magazines and map navigation (n=1). In addition, students who made fewer calls and played fewer games showed more symptoms of depression and anxiety (n=1). With regard to anxiety, one study applied three different conditions to assess whether anxiety would be greater when limiting access to the smartphone, the PSU did not significantly predict anxiety in any of the experimental conditions.

Some studies have assessed other outcomes that may be associated with PSU. In one study, students at risk of developing an eating disorder, for example, had a higher prevalence of possible PSU. In another study, the presence of dependent personality disorder led to a 3.1x greater chance of university students having smartphone addiction, while bipolar spectrum disorder and depressive disorder increased the risk of addiction by 4.2x. The development or exacerbation of sleep disorders was also significantly correlated with PSU (n=8). In addition, a greater suicidal tendency was observed in students with PSU (n=1). In other studies, SA was associated with alexithymia (n=1), and predictive of more severe psychological distress in men than in women (n=1). Longitudinally, more smartphone time was associated with irritable mood and stress (n=1), and PSU was positively correlated with sleep procrastination over time (n=1).

DISCUSSION

This systematic review brings together evidence of associations between smartphone use and mental disorders among university students. The results represent statistical correlations found in the included studies; however, they should be considered with caution, as temporality is a crucial condition for causal explanations of the observed associations.[67] In addition, the ubiquity of screens in today's digital world makes it difficult for studies to compare these students with groups who do not use smartphones. PSU has been a recurring term in studies to designate the excessive or addictive use of smartphones. However, a healthy time of smartphone use for the university population has not yet been established. In 2013, the American Academy of Pediatrics established some healthy limits for daily screen use for children and adolescents, but university students, in general, have no parental control over the time spent on their smartphones.[68] Consistently, in 45 of the 48 included studies, positive associations were observed between excessive smartphone use and higher mental disorder scores. Depression, anxiety, and stress were most positively associated with smartphone use in this review.

Recently, a meta-analysis of 201 studies on the overall prevalence and risk factors for mental health problems among medical students also found a high prevalence of depression, anxiety, stress, as well as sleep disorders, psychological distress, and suicidal ideation. In line with our results, the main risk factors were being female, problematic internet or smartphone use and young age.[69] A comprehensive meta-analytical study in the general population had already observed that women, university students and young adults had the highest levels of anxiety, depression, sleep problems and suicidal ideation.[70]

Depression, anxiety, and stress were considered key aspects of mental health in university students,[71] and have been strongly correlated with PSU.[72] A longitudinal investigation, however, found significant fluctuations in PSU levels and depressive symptoms from the first to the third year of graduation. Research that assessed students in four waves found that PSU at time 2 (T2) was predictive of depressive symptoms at time 3 (T3), and depressive symptoms at T2 were predictive of PSU at T3 (n=1). In fact, the presence of depressive symptoms may be part of the set of factors that lead students to develop excessive smartphone use, especially with the increased time under

pressure of the academic environment. Here, students with higher depressive symptom scores had a higher risk of PSU, longitudinally (n=1).

Easy access to the internet and popular social media apps adds to the risk of smartphone overuse. These platforms are designed to provoke a continuous need to be online.[13] Students can develop a state of generalized apprehension when they feel that their peers are online, having rewarding experiences, and they are absent. This is a characteristic feeling of FoMO.[73] Today, social media can make people realize that others are having better experiences.[74] Therefore, it is plausible that the relationship between smartphones and mental well-being depends on how smartphone use is moderated by FoMO.[75] Nomophobia, the uncontrollable fear of being away from the cell phone, may be related to the university student's emotional adaptability, i.e. the ability to cope with the longing for a circle of coexistence that has been broken. This adaptability plays an important role in the fear of missing out.[76]

Excessive smartphone use has also influenced the quality of sleep of university students (n=8) This can be explained by the perceived discrepancy between an individual's biological clock and social time. Traditionally, university students have to adapt to varying schedules of academic and social activities and it has already been established that pronounced social jet lag is associated with mental disorders.[77] Suicidality was also observed in one study, but it is noteworthy. Excessive smartphone use was associated with higher suicidality in university students (n=1). In fact, an increase in the prevalence of suicidal ideation in university students has been observed and among the associated factors is excessive smartphone use.[68,78] However, the presence of depressive symptoms seems to mediate the relationship between smartphone use and suicidal ideation (n=1). If we consider the current increase in the number of online classes, this could be an aggravating factor for the increase in psychopathologies, including depression.[68] In fact, the associations of PSU with depressive and anxiety symptoms were more pronounced in the online learning group in one study in this review, with large effect sizes (n=1). It is important to consider that the isolation and decreased social support associated with the past advent of the COVID-19 pandemic have likely added factors to the increased risk of suicide in young people, and not just the excessive use of smartphones.[79]

The few longitudinal studies in this review also found results with negative impacts of smartphone use on the psychological state of participants. However, it seems that the purpose of cell phone use, as well as characteristics of the individuals themselves, influenced the associations and deserve to be highlighted. One study found that more time spent on the smartphone was associated with a worsening of mood, but a greater number of phone calls showed an improvement in students' mood. In addition, increased stress was predictive of increased smartphone use and the association between PSU and depression was, in fact, mediated by stress (n=1). In another study, higher scores of social anxiety disorder and depressive symptoms presented a high risk of USP, i.e. the development of psychopathology may precede the development of USP over time in this population.

In a more recent publication included in the review, a positive relationship was observed between PSU and sleep procrastination over time, but it was also a reciprocal relationship, and it was not possible to establish causality, even with the longitudinal design.[80] Anxiety is a significant independent predictor of bedtime procrastination.[81] Boredom tendency, cell phone addiction, negative emotions and bedtime procrastination were positively correlated with each other. Boredom proneness predicted cell phone addiction, which was associated with higher levels of negative emotions, which were associated with bedtime procrastination.[82] One study found a positive association between PSU and sleep disturbances in both initial and follow-up measurements. Even with this in mind, it is not possible to say whether PSU delays sleep onset or whether lack of sleep increases the amount of time spent using a cell phone before bed, reducing healthy sleep time and creating a snowball effect.

Some limitations of this review are related to the self-reporting of smartphone usage time, which can introduce weaknesses in the data. It is recommended to use the technological resources of the smartphones themselves, which allow stratification of the time spent studying, working or leisure. In addition, the period of pandemic and social isolation, which coincided with the time interval considered for inclusion of the articles, adds a layer of complexity to the interpretation of the results. During this period, there was a significant increase in the use of the internet for everyday activities, which was reflected in the increased use of smartphones.

CONCLUSION

Important data was collected on university students' interaction with smartphones and their psychological well-being. Depression, anxiety and stress were the main mental disorders found among university students in this survey. Online studies represented an additional risk of developing mental health problems in this population. Students with higher scores on depressive symptoms are at greater risk of problematic smartphone use, and the constant availability of devices may be a risk factor for smartphone addiction.

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