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Impulsivity mediates the relationship between sleep quality and interpersonal functioning: a cross-sectional study in a sample of university students

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Abstract

Background Amid the current mental health pandemic, research continues to investigate potential contributors associated with increasing levels of negative mental health. Among such contributors is sleep, which is vital for physiological and psychological functioning with potential downstream behavioral consequences, including in relation to impulsivity and social functioning. Given the significant rates of disordered sleep behaviors reported in the literature, our study sought to investigate the relationship between sleep quality, impulsivity and interpersonal functioning among university students.

Methods An anonymous online survey was administered to university students (Ages 18+; $N=526$; 33% male, 67% female) addressing demographics, sleep quality, impulsivity, and interpersonal functioning.

Results Our findings indicate a substantial proportion of students reporting poor sleep quality and impulsivity. Moreover, higher levels of impulsivity and lower interpersonal functioning were associated with poor sleep quality. Mediation analysis revealed a significant mediating role of attentional impulsivity in the relationship between sleep quality and interpersonal functioning.

Conclusions Repeated reports of significant levels of impulsivity underlying numerous psychiatric disorders, its prevalence socially, and the fundamental issue that impulsivity reflects (i.e., lack of self-control/self-discipline/self-regulation), suggests a necessity to reorient therapeutic efforts towards the root of the problem. Thus, efforts should seek to maximize preventative behaviors that strengthen the individual (e.g., improving sleep-related behaviors), and contribute to the building of character/virtue, through self-discipline, perseverance and consistency, in order to reduce negative outcomes (e.g., impulsivity, dysfunctional interpersonal functioning).

Keywords Sleep quality, Impulsivity, Interpersonal functioning, Self-discipline, University students, Cross-sectional

Introduction

Research continues to indicate growing levels of negative mental health among university students (e.g., Beiter et al., 2015; Bruffaerts et al., 2018; Emmerton et al., 2024; Limone and Toto, 2022; Lipson et al., 2019; Torales et al., 2019; Twenge et al., 2010). The correlates to negative mental health are many, and scientific research continues to seek further understanding of such correlates in all contexts, including in the university student population,

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in order to provide potential solutions. Among the numerous correlates identified in the scientific literature, including in our previous work, sleep continues to be an important source of stress/concern (Almojali et al., 2017; Alotaibi et al., 2020; Beiter et al., 2015; Dietch et al., 2016). Furthermore, substantial proportions of college students in the United States and globally report poor sleep quality and/or an inadequate amount of sleep (Albqoor and Shaheen, 2021; Becker et al., 2018; Dinis and Braganca, 2018; Lund et al., 2010; Mbous et al., 2022; Ramon-Arbues et al., 2022).

Proper sleep quality and appropriate/healthy levels of sleep play a significant restorative role physiologically, immunologically, hormonally, neurologically, and psychologically (Asif et al., 2017; Benington and Heller, 1995; Dattilo et al., 2011; Kim et al., 2015; Scott et al., 2021). Thus, the consequences of disturbed or inadequate sleep can have broad pathological implications ranging from the cellular to the behavioral levels. Under such situations, at the neurobehavioral level, executive functioning, which regulates basic behaviors such as attention (Logue and Gould, 2014) and impulse control (Hayashi et al., 2017; Hayashi and Washio, 2020; Jones et al., 2021; Narvaez et al., 2012; Reynolds et al., 2019), is reduced.

Effective/appropriate executive functioning is necessary in the processes of error detection (Simoes-Franklin et al., 2010; van Gaal and Lamme, 2012), emotional regulation (Mohammed et al., 2022) and social cue processing (Dias et al., 2022). Therefore, when negatively impacted by factors such as sleep deprivation, error detection becomes dysregulated (Thomas et al., 2000; Tsai et al., 2005). Additionally, emotional dysregulation can result, potentially due to a dysfunctional metabolism impacting amygdalar regulation (Benington and Heller, 1995; Thomas et al., 2000; Wu et al., 2006; Yoo et al., 2007). Consequently, this can lead to an enhanced sensitivity to negative stimuli, decreased responsiveness to long-term positive events, reduced positive moods, amplified emotional sensitivity, and increased irritability (Dinges et al., 1997; Sanz-Arigita et al., 2021; Yoo et al., 2007; Young and Nusslock, 2016; Zohar et al., 2005). The potential for more serious negative behaviors, including but not limited to, suicidal thoughts and behaviors, is also present (e.g., Pigeon et al., 2012; Tsai et al., 2005; Vedaa et al., 2019; Vyazovskiy and Delogu, 2014; Wu et al., 2006). Such consequences/behaviors not only impact the individual experiencing them, but also the social surroundings of the individual, as their behaviors can influence the way in which they interact with others.

Additionally, as indicated above, executive functioning is important in impulse control. A deficiency in impulse control can lead/contribute to a wide range of negative, disinhibited and often risky behaviors. Such behaviors include, but are not limited to, excessive texting, texting while driving, drug abuse and/or inappropriate alcohol use and risky sexual behaviors and any consequences resulting from such behaviors (Hayashi et al., 2017; Hayashi and Washio, 2020; Jentsch et al., 2014; Jones et al., 2021; Killgore et al., 2006; Narvaez et al., 2012; Potenza and de Wit, 2010; Reynolds et al., 2019). Related, inappropriate impulse control can also lead to adverse/dysfunctional social behaviors evident in such behaviors as inappropriate peer influence, social anxiety, aggression and antisocial personality disorder (aan Het Rot et al., 2015; DeBono et al., 2011; Dixon et al., 2017; Krakowski, 2003; Roeser et al., 2018; Swann et al., 2010). In addition to the potential effects of emotional dysregulation discussed above, the presence of inappropriate social behaviors, including dysregulation in social cue processing (Gilboa-Schechtman and Shachar-Lavie, 2013; Ruz and Tudela, 2011), can also subsequently influence interpersonal functioning (defined as intimacy and empathy; DSM-5) and the formation and maintenance of relationships (Albers, 2012; Chiu et al., 2021; Crocker et al., 2017). Ultimately, healthy social relationships, and therefore appropriate interpersonal functioning, have been shown to influence the overall well-being of the individual (e.g., Hawkley and Cacioppo, 2010; Hefner and Eisenberg, 2009).

Therefore, given 1) the prevalence and plethora of negative outcomes associated with disordered sleep behaviors on aspects of executive functioning (such as error detection, emotional regulation and impulsivity), 2) the various relationships reported in the literature between sleep, executive functioning, emotional regulation and interpersonal relationships, and 3) the importance of quality/healthy relationships in the midst of the mental health "pandemic", our study sought to investigate the relationship between sleep quality and interpersonal functioning and the potential mediating role of impulsivity in such a relationship, in a sample of university students.

Methods

This survey research was conducted in compliance with Federal Law pertaining to the protection of human research subjects. Prior to administration of the survey, Franciscan University of Steubenville Institutional Review Board (IRB) approval was obtained (#2022–4). Our study consisted of a convenience sample of university/college (undergraduate and graduate) students from Franciscan University of Steubenville, OH, United States. An anonymous survey was sent via the university student email address, to all students taking classes at Franciscan University, who were at least 18 years of age. Over the course of two weeks (April 19th – May 3rd, 2022), the survey was administered through the online survey

engine SurveyMonkey®. Prior to being provided access to the survey, participants were directed to a consent form, which detailed the confidentiality and the nature of the study and explained that participation in the study implied consent to analyze and publish the overall results. Participants who did not provide consent were directed to the *Disqualification Page*. The projected time of completion of the survey was approximately 15 min. The final page of the survey included a link to enter an optional drawing for one (1) of four (4) VISA gift cards ($25 each). The participants were informed that there was no possibility of linking the drawing information to that of the survey and that their information would remain confidential.

Exclusion criteria

Any individual who (1) was younger than 18 years of age ($n=0$), (2) was not a student at Franciscan University of Steubenville ($n=4$), (3) was an online-only student ($n=185$), or (4) responded "No" to the consent question ($n=3$) was immediately directed to the *Disqualification Page*. Additionally, 75 individuals exited the survey prior to completing any or all of the above required criteria.

Exclusion criteria included any individual who: (1) did not complete the survey question regarding their age ($n=14$), or (2) did not provide a response to ($n=46$) or complete the required questions ($n=21$) for the Pittsburgh Sleep Quality Index (PSQI). The final number of participants whose responses met inclusion criteria was 526 (89% of the 593 respondents who started the survey; 22% of the 2386 students in the target population who received the invitation email), which is representative of the target population.

Survey structure

Demographic questions

Demographic questions included: age, sex, primary major, and living status during the school year. Participants were also asked questions regarding the average number of hours a day they spend on academics outside of scheduled classes, number of credit hours currently being taken and the number of semesters they have spent living on campus at Franciscan University (including the semester currently underway), as well as on other university campuses (i.e., not Franciscan University).

Additionally, participants were asked to complete the "Daily Spiritual Experiences" domain of the Brief Multidimensional Measurement of Religiousness/Spirituality, which is comprised of a number of domains that address various aspects pertaining to religiosity and spirituality, which can be utilized separately (Fetzer Institute / National Institute on Aging Working Group, 2003). The "Daily Spiritual Experiences" domain consisted of 7 items measured on a six-point Likert scale (1 = *Many times a day* to 6 = *Never or almost never*).

Pittsburgh sleep quality index (PSQI)

The Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) was used to assess participants' sleep quality and disturbances over the past month. Subjects were asked questions regarding various aspects of their sleep habits, including the rating of statements on various Likert scales (e.g., 0 = *Not during the past month* to 3 = *Three or more times a week*). The PSQI is comprised of seven components (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, daytime dysfunction), which are "standardized versions of areas routinely assessed in clinical interviews of patients with sleep/wake complaints" (Buysse et al., 1989). The scores of the seven components are then summed to create a global/total PSQI score (ranging from 0–21), with higher scores being indicative of worse sleep quality. Moreover, a global PSQI score greater than 5 has been previously indicated as a reliable cutoff for indicating "poor" versus "good" sleepers (Buysse et al., 1989). Thus, going forward, in this study, in regards to our findings, sleep quality refers to the broad definition reflected in the PSQI consisting of the seven components addressed above, addressing both aspects of sleep quality and sleep disturbance.

The question regarding a roommate or bed partner originally included additional components scored on a four-point Likert scale. However, for the purpose of our survey, this question, which does not contribute to the global score, was modified to simply ask if the participant had a roommate and if so, whether they were in the same room or another room.

Barratt impulsiveness scale (BIS-11)

Our survey also included the Barratt Impulsiveness Scale Version 11 (BIS-11) (Patton et al., 1995) to assess various components of trait impulsivity. Participants were asked to indicate the appropriate response (on a four-point Likert scale:*Rarely/Never* to *Almost always/Always*) regarding various statements pertaining to ways in which they act and think. A total score (Total BIS) was calculated, as well as scores for each of the three subscales: *Attentional Impulsiveness* (AttImp), *Motor Impulsiveness* (MotImp), *Non-planning Impulsiveness* (NpImp), with higher scores reflecting higher impulsivity for both the subscales and overall scores.

Cronbach's alpha indicated good internal consistency for Total BIS (α = 0.84), and acceptable for the AttImp and NpImp (α = 0.75 and 0.72, respectively) subscales and questionable for the MotImp (α = 0.64) subscale.

Functional idiographic assessment template—questionnaire—short form (FIAT-Q-SF)

The short form of the Functional Idiographic Assessment Template—Questionnaire (FIAT-Q-SF) (Darrow et al., 2014) was utilized to assess various aspects associated with the participants' interpersonal relationships/functioning. Individuals were asked to indicate on a six-point Likert scale (*Strongly disagree* to *Strongly agree*) whether or not the statement applies to them. Based on Darrow and colleagues (2014), total overall scores (Total FIAT) were calculated, as well as total scores for each of the following factors:*Avoidance of Interpersonal Intimacy* (AvdInt), *Argumentativeness or Disagreement* (ArgDis), *Connection and Reciprocity* (ConRec), *Conflict Aversion* (ConAve), *Emotional Experience and Expression* (EmoExp), and *Excessive Expressivity* (ExcExp). Higher FIAT-Q-SF subscale or overall scores are indicative of worse interpersonal functioning.

Cronbach's alpha pertaining to the FIAT-Q-SF indicated good internal consistency for the Total FIAT (α = 0.85), as well as the AvdInt, ArgDis, ConAve and ExcExp subscales (α = 0.88, 0.82, 0.81, 0.82, respectively). Additionally, Cronbach's alpha indicated acceptable internal consistency for the ConRec subscale (α = 0.72) and questionable internal consistency for the EmoExp subscale (α = 0.64).

Statistical analysis

Analyses were conducted on all data remaining following the application of the exclusion criteria (n = 526) using R version 4.3.0, SigmaPlot version 14.0 (Systat Software, Inc.) and Jamovi version 2.3.15. Proportions tests were utilized to assess (1) the percentage of individuals scoring within *poor* versus *good* sleep quality, (2) differences in the percentage of males and females scoring within *poor* sleep quality and (3) differences in the proportion of those reporting poor sleep quality within each of the BIS-11 scoring categories. Additionally, independent measures t-test (two-tailed) were used to assess (1) sex differences in total/global PSQI, BIS-11 and FIAT-Q-SF scores, (2) sex differences in the subscales/components of each scale utilized in this study (i.e., PSQI, BIS-11, FIAT-Q-SF), and (3) differences in BIS-11 and FIAT-Q-SF total scores, as well as the individual subscales, between participants reporting *good* vs *poor* sleep quality (as measured by the PSQI). Pearson correlations were utilized to assess the relationships between the PSQI, BIS-11 and FIAT-Q-SF. Given (1) the various correlations between the variables measured in this study, in addition to (2) previous literature (addressed above) indicating a relationship between sleep and factors associated with both impulsiveness and social relationships, as well as (3) previous research addressing impulsivity as a mediator between variables associated with sociality and well-being (Reichl et al., 2023), mediation analysis using Baron and Kenny's criteria (Baron and Kenny, 1986; Shrout and Bolger, 2002), as well as 1000 bootstrapping replicates (Shrout and Bolger, 2002), was utilized to investigate the potential relationship between sleep quality (predictor) and interpersonal functioning (outcome), and the potential mediating effect of impulsiveness (mediator) on such a relationship. Differences were considered significant at $p < 0.05$.

Results

Demographics

The distribution of participants in this survey was 33% male and 67% female, which is relatively representative of the student body at Franciscan University. The data for the demographic questions outlined above are shown across sex in Supplementary Table 1 (See Additional File 1).

Sleep quality (PSQI)

In relation to sleep quality, as measured by the PSQI, average global PSQI scores and average scores for each of the components (as outlined by Buysse et al. (1989)) are shown in Table 1. In this regard, analysis indicated significantly higher global PSQI scores in females relative to males ($p < 0.05$). Additionally, in relation to the PSQI subscales, females scored significantly higher in both *Sleep disturbance* ($p < 0.05$) and *Daytime dysfunction due to sleepiness* ($p < 0.01$) relative to males. All other comparisons were not significant (all $p > 0.05$).

Analysis of sleep quality (PSQI), as defined by Buysse et al. (1989), indicated that a significantly higher proportion [χ^2 (1, N = 454) = 97.80, $p < 0.001$] of participants reported *poor* (66.5%) relative to *good* (33.5%) sleep quality. Figure 1 portrays the distribution of participants across global PSQI scores. Additionally, a significantly higher percentage [χ^2 (1, N = 454) = 4.78, $p < 0.05$] of females (70.0%) relative to males (59.2%) reported scores indicating *poor* sleep quality.

Impulsivity (BIS-11)

Average total BIS-11 scores and the average sum for each subscale (*Attentional Impulsiveness*, *Motor Impulsiveness* and *Non-planning Impulsiveness*) and standard errors of the mean are reported for the overall sample (i.e., sexes combined) and across the sexes in Table 1, as well as statistics (i.e., t-statistics and r-squared

Table 1 Average PSQI, BIS-11 and FIAT-Q-SF scores in overall sample, as well as sex differences

Scale/Subscale	Overall	Male	Female	t	r^2
PSQI					
Global PSQI	7.17 (0.14)	6.71 (0.24)	7.39 (0.18)	2.260*	0.011
Sleep duration	0.49 (0.03)	0.54 (0.06)	0.47 (0.04)	-1.116	0.002
Sleep disturbance	1.21 (0.02)	1.13 (0.04)	1.25 (0.03)	2.429*	0.011
Sleep latency	1.32 (0.04)	1.27 (0.07)	1.34 (0.05)	0.762	0.001
Daytime dysfunction due to sleepiness	1.68 (0.03)	1.56 (0.06)	1.74 (0.04)	2.587**	0.013
Sleep efficiency	0.79 (0.04)	0.79 (0.07)	0.80 (0.05)	0.146	0.000
Overall sleep quality	1.19 (0.03)	1.19 (0.05)	1.19 (0.03)	-0.093	0.000
Sleep medication use	0.46 (0.04)	0.30 (0.06)	0.54 (0.05)	2.844	0.015
BIS-11					
Total BIS	64.81 (0.48)	64.46 (0.84)	64.97 (0.59)	0.499	0.000
Attentional Impulsiveness	18.50 (0.19)	17.59 (0.33)	18.93 (0.23)	3.306**	0.021
Motor Impulsiveness	21.53 (0.19)	22.15 (0.33)	21.24 (0.23)	-2.268*	0.010
Non-planning Impulsiveness	24.78 (0.22)	24.72 (0.39)	24.80 (0.27)	0.170	0.000
FIAT-Q-SF					
Total FIAT	86.87 (0.85)	86.13 (1.47)	87.19 (1.04)	0.576	0.001
Avoidance of Interpersonal Intimacy	27.49 (0.43)	27.28 (0.71)	27.58 (0.54)	0.325	0.000
Argumentativeness or Disagreement	16.95 (0.29)	18.10 (0.48)	16.45 (0.36)	-2.612**	0.015
Connection and Reciprocity	6.82 (0.13)	7.41 (0.25)	6.56 (0.16)	-2.954**	0.019
Conflict Aversion	10.42 (0.18)	9.17 (0.31)	10.96 (0.22)	4.610***	0.045
Emotional Experience and Expression	14.54 (0.20)	13.98 (0.39)	14.79 (0.24)	1.849	0.008
Excessive Expressivity	10.65 (0.23)	10.18 (0.37)	10.85 (0.29)	1.319	0.004

PSQI: Global PSQI—Male: $n = 147$, Female: $n = 307$; *Sleep duration* and *Sleep disturbance*—Male: $n = 174$, Female: $n = 352$; *Sleep latency*—Male: $n = 172$, Female: $n = 350$; *Daytime dysfunction due to sleepiness*, *Overall sleep quality*, and *Sleep medication use*—Male: $n = 171$, Female: $n = 352$; *Sleep efficiency*—Male: $n = 150$, Female: $n = 308$. *BIS-11*—Male: $n = 162$, Female: $n = 341$. *FIAT-Q-SF*—Male: $n = 136$; Female: $n = 312$. Data is reported as mean (Standard error of the mean). t-statistic and r-squared based on two-tailed independent measures t-tests. Degrees of freedom = sum of the number of males and females (provided for each scale/subscale) minus 2

*$p < 0.05$

**$p < 0.01$

***$p < 0.001$

values) for the appropriate tests. Average scores are also shown for Total BIS and each subscale across poor and good sleep quality (as measured by the PSQI), as well as appropriate statistics in Table 2. Based on the total score cut-offs addressed in Stanford and colleagues (2009), 26.2% of respondents would be categorized as "highly impulsive" (72 or higher), 62.8% as "within normal limits of impulsiveness" (52-71) and 10.9% as "an individual that is either extremely overcontrolled or who has not honestly completed the questionnaire" (< 52).

BIS-11 across sex

Analysis of the BIS-11 across the sexes (Table 1; Fig. 2A) indicated no significant difference ($p > 0.05$) between males and females in the average total BIS-11 scores. Analysis also revealed significantly higher ($p < 0.01$) average *Attentional Impulsiveness* scores among females relative to males, while males scored significantly higher ($p < 0.05$) in *Motor Impulsiveness* relative to females. In relation to *Non-planning Impulsiveness*, there was no significant sex difference in average scores ($p > 0.05$).

BIS-11 and sleep quality

In relation to sleep quality and impulsivity, as measured by the PSQI and BIS-11, respectively, of the individuals scoring within the category of "highly impulsive", 70.5% reported poor sleep quality. Additionally, of those scoring "within normal limits of impulsiveness", 55.7% reported poor sleep quality, while 43.6% of those scoring in the lowest category of impulsiveness (< 52) reported poor sleep quality. Proportions test indicated a significantly higher percentage [χ^2 (2, $N = 503$) = 13.76, $p < 0.01$] of poor sleep quality among those reporting high impulsivity (score 72 or higher) relative to both other groups (score between 52–71: $p < 0.05$; score < 52: $p < 0.01$).

Additionally, in relation to impulsivity across sleep quality (Table 2; Fig. 2B), analysis indicated that those

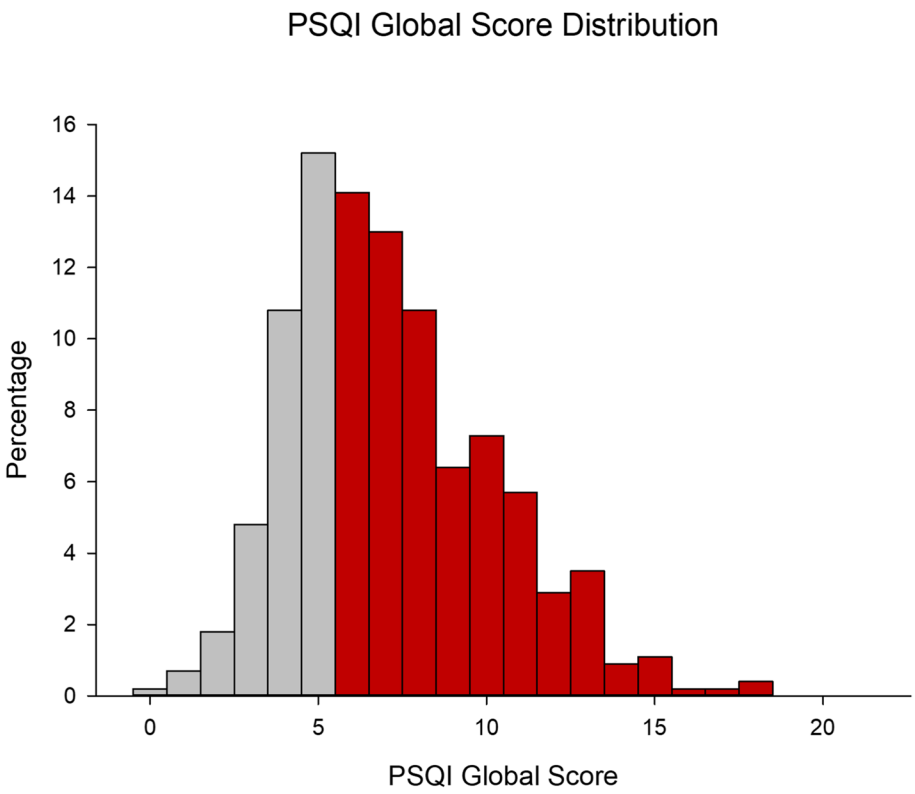

Fig. 1 Distribution (percentage) of participants across sleep quality (Global PSQI scores). Coloring indicates *poor* (red) versus *good*(gray) sleep quality as defined by Buysse et al. (1989), i.e., scores greater than 5 indicate poor sleep quality

Table 2 Average scores across BIS-11 and FIAT-Q-SF across poor and good sleep quality (PSQI)

Scale/Subscale	Poor	Good	t	r^2
BIS-11				
Total BIS	66.56 (0.64)	61.97 (0.85)	4.207***	0.039
Attentional Impulsiveness	19.42 (0.25)	16.72 (0.33)	6.358***	0.084
Motor Impulsiveness	21.95 (0.26)	21.13 (0.34)	1.891	0.008
Non-planning Impulsiveness	25.20 (0.29)	24.12 (0.41)	2.123*	0.010
FIAT-Q-SF				
Total FIAT	89.53 (1.09)	83.06 (1.57)	3.359***	0.028
Avoidance of Interpersonal Intimacy	28.65 (0.55)	25.54 (0.79)	3.213**	0.026
Argumentativeness or Disagreement	17.39 (0.38)	16.57 (0.56)	1.210	0.004
Connection and Reciprocity	6.57 (0.15)	7.05 (0.27)	-1.656	0.007
Conflict Aversion	10.51 (0.25)	10.36 (0.32)	0.359	0.000
Emotional Experience and Expression	15.05 (0.26)	13.76 (0.38)	2.835**	0.020
Excessive Expressivity	11.36 (0.32)	9.78 (0.39)	2.950**	0.022

Poor and *Good*: poor and good sleep quality, respectively, as measured by the PSQI (BIS-11: Poor: $n = 293$, Good: $n = 147$; FIAT-Q-SF: Poor: $n = 266$, Good: $n = 125$). Data is reported as mean (Standard error of the mean). t-statistic and r-squared based on two-tailed independent measures t-tests). Degrees of freedom = sum of the number of subjects reporting Good and Poor sleep quality for each scale (provided in the table) minus 2

*$p < 0.05$

**$p < 0.01$

***$p < 0.001$

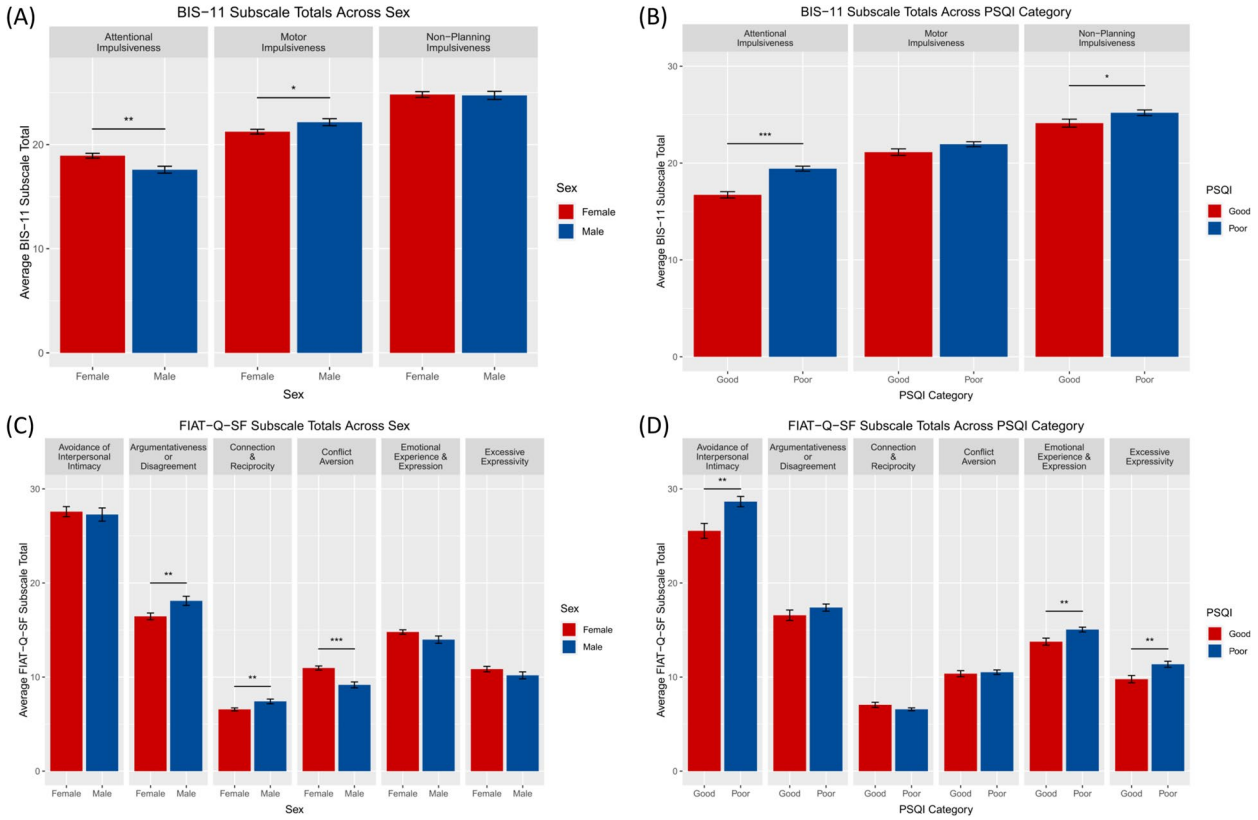

Fig. 2 Average impulsivity and interpersonal functioning subscale total scores across sex and sleep quality category. **A** BIS-11 (impulsiveness) subscale totals across sex; **B** BIS-11 subscale totals across PSQI category (*poor* vs *good* sleep quality); **C** FIAT-Q-SF (interpersonal functioning) subscale totals across sex; **D** FIAT-Q-SF subscale totals across PSQI category. Data shown as mean ± standard error of the mean. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

reporting *poor* sleep quality indicated significantly higher average BIS-11 total scores ($p < 0.001$) than those reporting *good* sleep quality.

Analysis also revealed significantly higher average *Attentional Impulsiveness* ($p < 0.001$) and *Non-planning Impulsiveness* ($p < 0.05$) scores, but not *Motor Impulsiveness* scores ($p > 0.05$), in participants reporting *poor* relative to *good* sleep quality.

Interpersonal functioning (FIAT-Q-SF)

Average total FIAT-Q-SF scores and the average sum for each subscale (*Avoidance of Interpersonal Intimacy*, *Argumentativeness or Disagreement*, *Connection and Reciprocity*, *Conflict Aversion*, *Emotional Experience and Expression*, *Excessive Expressivity*) and standard errors of the mean are reported for the overall sample (i.e., sexes combined) and across the sexes in Table 1, as well as the appropriate statistics (i.e., *t*-statistics and *r*-squared values). Average scores are also shown for Total FIAT and each subscale across poor and good sleep quality (as measured by the PSQI), in addition to the appropriate statistics in Table 2.

FIAT-Q-SF across sex

In relation to the FIAT-Q-SF across the sexes (Table 1; Fig. 2C), analysis of the total FIAT-Q-SF scores indicated no significant difference between males and females ($p > 0.05$). Additional analysis indicated various sex differences across the FIAT-Q-SF subscales. Specifically, males reported significantly higher scores relative to females in *Argumentativeness or Disagreement* and *Connection and Reciprocity* (both $p < 0.01$), while females reported significantly higher *Conflict Aversion* scores ($p < 0.001$). All other comparisons were not significant (all $p > 0.05$).

FIAT-Q-SF and sleep quality

Analysis pertaining to sleep quality (PSQI) and interpersonal functioning (FIAT-Q-SF) (Table 2; Fig. 2D) indicated significantly higher ($p < 0.001$) Total FIAT scores in those reporting *poor* relative to *good* sleep quality. Additionally, analysis indicated significantly higher average *Avoidance of Interpersonal Intimacy*, *Emotional Experience and Expression* and *Excessive Expressivity* scores

(all $p < 0.01$) in those reporting *poor* relative to *good* sleep quality.

Correlation of PSQI, BIS-11 and FIAT-Q-SF

Correlation analysis indicated various significant positive relationships between the variables measured pertaining to sleep quality (Global PSQI), impulsivity (BIS-11; Total BIS, *Attentional Impulsiveness, Motor Impulsiveness*, *Non-planning Impulsiveness*), and interpersonal functioning (FIAT-Q-SF; Total FIAT, *Avoidance of Interpersonal Intimacy*, *Argumentativeness or Disagreement*, *Connection and Reciprocity*, *Conflict Aversion*, *Emotional Experience and Expression*, *Excessive Expressivity*) (Fig. 3).

Mediation analysis of PSQI, BIS-11 and FIAT-Q-SF

Mediation analysis was performed to assess the potential mediating role of impulsiveness (as measured by the BIS-11 subscales; *Attentional Impulsiveness, Motor Impulsiveness*, *Non-planning Impulsiveness*; M = mediator in Fig. 4) on the relationship between sleep quality (as measured by the Global PSQI Score; PSQI/IV = independent variable in Fig. 4) and interpersonal functioning (as measured by the Total FIAT-Q-SF Score; FIAT/DV = dependent variable in Fig. 4). Figure 4 shows both the hypothesized conceptual model (Fig. 4A) and the final model (Fig. 4B). Significant mediation pathways, including the indirect relationships, shown in-text (full results shown in Supplementary Table 2 (See Additional File 2)), revealed that the total effect of sleep quality (PSQI) on interpersonal functioning (FIAT-Q-SF) was significant (H1: $\beta = 1.727$, $t = 6.09$, $p < 0.001$).

With the inclusion of the mediating variables (BIS-11: *Attentional Impulsiveness, Motor Impulsiveness*, *Non-planning Impulsiveness*), the impact of sleep quality (PSQI) on interpersonal functioning (FIAT-Q-SF) was still found significant ($\beta = 0.747$, $t = 2.48$, $p < 0.05$).

The indirect effect of PSQI on FIAT-Q-SF was found significant through *Attentional Impulsiveness* ($\beta = 0.987$, $SE = 0.180$, $t = 5.47$, $p < 0.001$, 95% $CI = 0.678$, 1.392). However, the indirect effect of PSQI through both *Motor Impulsiveness* ($\beta = -0.116$, $t = -1.76$, $p = 0.079$) and

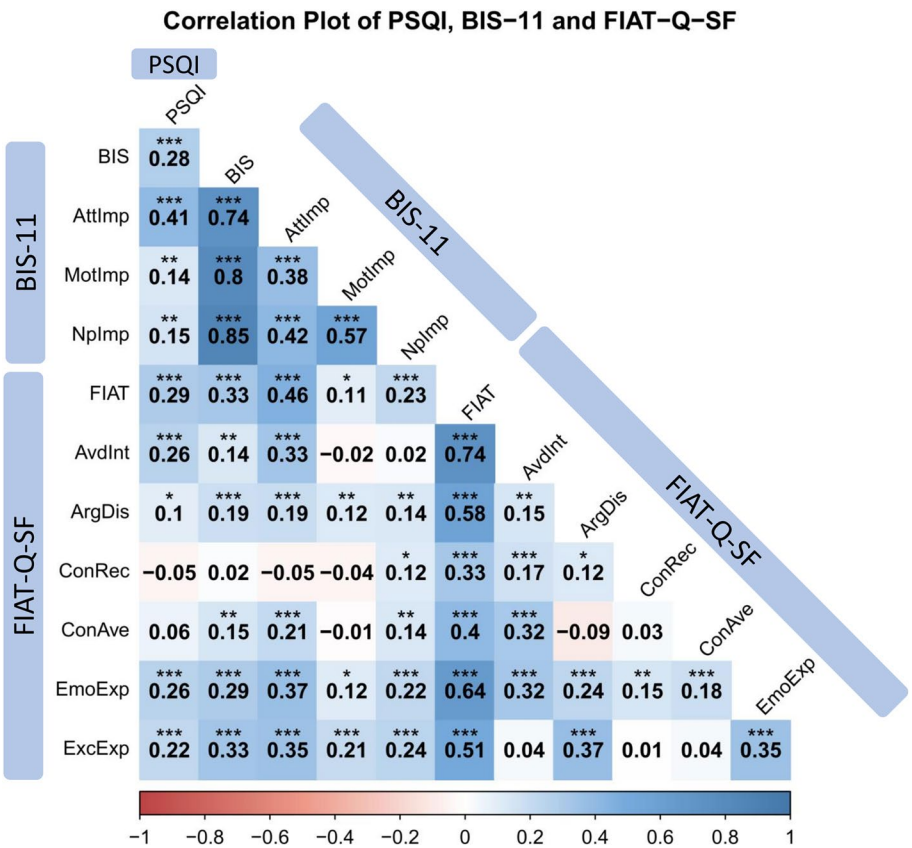

Fig. 3 Correlation plot of sleep quality (PSQI), impulsivity (BIS-11) and interpersonal functioning (FIAT-Q-SF). *PSQI*: Global PSQI Score; *BIS-11*: BIS, Total BIS; AttImp, Attentional Impulsiveness; MotImp, Motor Impulsiveness; NpImp, Non-planning Impulsiveness; *FIAT-Q-SF*: FIAT, Total FIAT; AvdInt, Avoidance of Interpersonal Intimacy; ArgDis, Argumentativeness or Disagreement; ConRec, Connection and Reciprocity; ConAve, Conflict Aversion; EmoExp, Emotional Experience and Expression; ExcExp, Excessive Expressivity. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

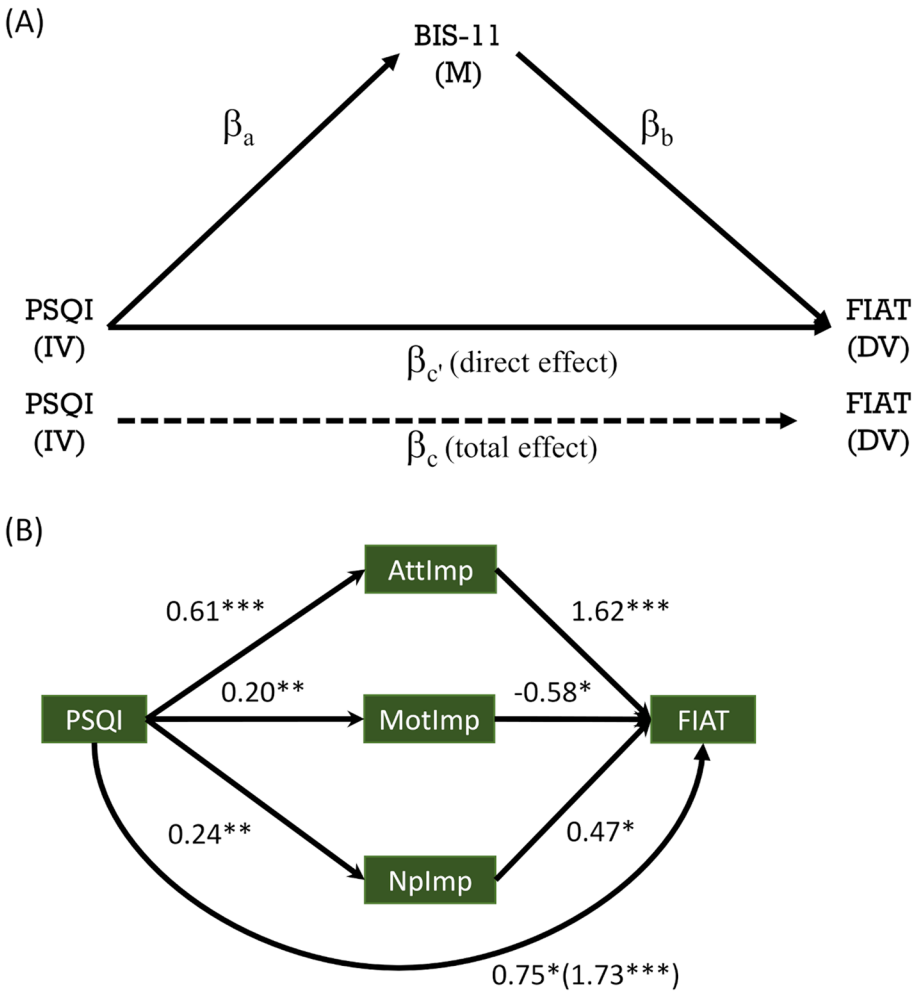

Fig. 4 The impact of sleep quality (PSQI) on interpersonal functioning (FIAT-Q-SF), mediated through impulsiveness (BIS-11). **A** Hypothesized mediation model; **B** Final mediation model. *PSQI*: Global PSQI Score; *BIS-11*: AttImp, Attentional Impulsiveness; MotImp, Motor Impulsiveness; NpImp, Non-planning Impulsiveness; *FIAT*: FIAT-Q-SF Total Score. Data represents estimates/betas—direct (total). IV, independent variable; DV, dependent variable; M, mediator. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Non-planning Impulsiveness ($\beta = 0.110$, $t = 1.74$, $p = 0.083$) were not significant.

Discussion

Our study sought to explore the relationship between sleep quality, impulsivity and interpersonal functioning, including the potential mediating role of impulsivity in the dynamic of sleep quality and interpersonal functioning. Our study confirms the significant presence of poor sleep quality and impulsivity among university students. Moreover, corroborating previous reports, our results support the relationship between disordered sleep behaviors, higher levels of impulsivity and lower interpersonal functioning (aan Het Rot et al., 2015; Beattie et al., 2015; Cheng et al., 2021; DeBono et al., 2011; Dorrian et al., 2019; Gillett et al., 2021; Gordon et al., 2021; Parks et al., 2021).

In relation to sex differences, females reported a significantly higher prevalence of poor sleep quality (Global PSQI) relative to males, supporting previous findings (Mong and Cusmano, 2016; Sa et al., 2019). Additionally, while there were no significant sex differences in *overall* impulsivity (Total BIS) and interpersonal functioning (Total FIAT), differences were observed between males and females in relation to some of the subscales, specifically, *Attentional Impulsiveness* and *Motor Impulsiveness* (for the BIS-11), as well as *Argumentativeness or Disagreement*, *Connection and Reciprocity*, and *Conflict Aversion* (for the FIAT-Q-SF).

Pertaining to the impact of sleep quality on impulsivity, individuals reporting *poor* sleep quality also reported significantly higher levels of *overall* impulsivity, and higher scores in the specific subscales of *Attentional* and *Non-planning Impulsiveness*. Moreover, individuals with

poor sleep quality also reported significantly higher total FIAT-Q-SF scores, indicating worse overall interpersonal functioning. Furthermore, within the specific subscales pertaining to interpersonal functioning, those reporting poor sleep quality also reported higher scores in *Avoidance of Interpersonal Intimacy*, *Emotional Experience and Expression* and *Excessive Expressivity*. Correlation analysis revealed significant relationships between sleep quality and various aspects of impulsivity and interpersonal functioning, corroborating the dynamics previously discussed. Additionally, mediation analysis indicated that *Attentional Impulsiveness* (AttImp), but not *Motor* (MotImp) or *Non-planning Impulsiveness* (NpImp), significantly mediated the relationship between sleep quality (PSQI) and interpersonal functioning (FIAT).

Interpersonal functioning, sleep and basic human functioning

In relation to interpersonal functioning, human interactions and relationships are fundamental/essential for normal human behavior (Hawkley and Cacioppo, 2010; Hefner and Eisenberg, 2009). Deprivation from such interactions is known to result in detrimental physiological, and ultimately, psychological effects (Leigh-Hunt et al., 2017; Loades et al., 2020; Sepulveda-Loyola et al., 2020; Taylor et al., 2018). However, the interaction between physiology and complex behaviors, such as those observed in human interactions, is not only bidirectional, but is also mediated/impacted by innate behaviors such as sleep. Through its impact on normal physiological functioning, including but not limited to, molecular and neuronal processes (e.g., Abel et al., 2013; Gaine et al., 2018; Leproult and Van Cauter, 2010), appropriate/inappropriate sleep behaviors (e.g., proper sleep vs insufficient sleep/sleep deprivation/sleep loss, etc.) can significantly impact basic human functioning in relation to learning, memory, decision-making, concentration/attention, and resilience/tolerance to stress (Chatburn et al., 2013; Chattu et al., 2018; Harrison and Horne, 2000; Hudson et al., 2020; Kechter and Leventhal, 2019; Maquet, 2001; Rasch and Born, 2013; Tempesta et al., 2018; Walker and Stickgold, 2005). Consequently, behaviors are impacted at an individual level (e.g., lead to irritability) with subsequent consequences on human relationships/interactions (e.g., Ben Simon et al., 2022; Chattu et al., 2018; Whiting et al., 2023). Our findings appear to support these dynamics through the relationships observed between sleep quality and both impulsivity and interpersonal functioning; specifically, lower sleep quality was associated with higher impulsivity scores and worse interpersonal functioning, thus reinforcing the importance of proper sleep in order to minimize the potential for the dysfunctional behaviors, interactions and relationships addressed above, which can, in the big picture, lead to dysfunction in various life situations including, but not limited to work, school environments, as well as intimate relationships. Additionally, our findings demonstrate that impulsivity (specifically attentional impulsivity) plays a significant role in mediating the relationship between sleep and interpersonal functioning.

While various pharmacological agents can be utilized to buffer the effects of some inappropriate sleep behaviors, such as sleep deprivation, their efficacy is often limited and temporary (e.g., Aggarwal et al., 2011). On the contrary, a more suitable treatment option may be adjustments in behavior such as improving sleep hygiene and routines, which are utilized in behavioral interventions, such as cognitive behavioral therapy for insomnia (CBT-I), which have been shown to be more effective in assisting individuals suffering from sleep issues such as insomnia in the long-term (Schlarb et al., 2018; Trauer et al., 2015; Wu et al., 2015). This further highlights the importance of focusing efforts on changing behaviors, rather than simply treating the symptoms associated with poor sleep.

Interpersonal functioning, sleep and executive function

It is important to note that *interpersonal functioning* is highly influenced by *executive functioning* (Lewis and Carpendale, 2009; Madjar et al., 2019) through various factors that can be modulated by *sleep*, such as emotional regulation, decision-making and attention, as indicated above. In fact, at a neurological level, amygdalar (emotion) and ventromedial prefrontal cortex (executive function) dysfunction (which have been shown to relate to sleep deprivation (Goldstein and Walker, 2014; Libedinsky et al., 2011)) have been reported to detrimentally impact emotional control, decision-making and attention (Dorrian et al., 2019; Wolf et al., 2014). This dynamic could potentially be underlying our findings pertaining to the impact of sleep quality on interpersonal functioning, particularly those aspects potentially influenced by emotional regulation (e.g., the *Emotional Experience and Expression* subscale of the FIAT-Q-SF).

Additionally, attention (which, again, is significantly impacted by executive functioning) is fundamental to all behavior and significantly informs decision-making at all stages of human life (e.g., Huttermann et al., 2018; Rangelov and Mattingley, 2020). The impact of poor sleep quality on executive functioning may also be reflected in the correlation/relationship between sleep quality and impulsivity, most especially in relation to *attentional impulsiveness* (which represents attention and cognitive instability (Patton et al., 1995)), and to a lesser extent, to motor (motor impulsiveness and perseverance) and non-planning (self-control and cognitive complexity)

impulsiveness. Going further into this dynamic, the mediating role of attentional impulsiveness in the relationship between sleep and interpersonal functioning is substantiated by both the aforementioned physiological consequences associated with disordered sleep behaviors, as well as the importance of attention in interpersonal functioning (Capozzi and Ristic, 2018; Pons et al., 2019; Taylor et al., 2016; Wolf et al., 2014). While these findings, based on the specific directionality investigated in our study, further highlight the importance of proper sleep, in order to minimize/avoid negative repercussions associated with both emotion and attention, which have broad implications on human behavior in general, it is necessary to be mindful of the multidirectional relationship between sleep and both emotion and attention (including in association with interpersonal functioning and impulsivity). This multidirectionality is potentially evident in regard to attention-deficit/hyperactivity disorder (ADHD), where ADHD can lead to disturbed sleep (in addition to emotional dysregulation and reduced attention) or, conversely, disturbed sleep can potentially lead to similar behaviors and symptoms to that of ADHD (Hvolby, 2015; Soler-Gutierrez et al., 2023). Thus, while additional analyses could investigate the alternate relationships between these variables (e.g., the potential mediating role of sleep in the relationship between impulsivity and interpersonal functioning), the implications of our findings and these complex relationships between the variables addressed above highlight the necessity, including at the clinical level, of ensuring that the primary problem is identified and addressed in order to avoid ineffective/inappropriate treatment strategies.

Role of sleep, attention and interpersonal functioning in daily life/functioning

Within the student population

While academics should be the fundamental objective of student life, they do not occur in a vacuum. As per society in general, students are functioning within a social structure that forms the university community and consists of social interactions. As indicated by our findings, students' interpersonal functioning was negatively impacted by poor sleep quality. Previous literature pertaining to university students has suggested that a lack of social interactions or the presence of negative social interactions have been associated with increased negative psychological consequences (e.g., increased perceived stress, increased proneness to boredom, increased negative emotional wellbeing) (e.g, Dumitrache et al., 2021; Fiori and Consedine, 2013). In addition, other research has indicated the beneficial role of positive social interactions, including indirectly through their influence on other positive behaviors such as physical activity, which has also been shown to be beneficial to well-being (e.g., Kawachi and Berkman, 2001; Reifman and Dunkel-Schetter, 1990; Vankim and Nelson, 2013). While the impact of social interactions on well-being has been recognized extensively in the literature, its relevance became particularly pronounced during COVID-19, a time when many individuals were deprived of in-person social interactions, contributing to a decline in mental health (e.g., Bzdok and Dunbar, 2020; Dumitrache et al., 2021).

Another fundamental aspect pertaining to the university student population that warrants attention is the impact of the students' lifestyle (e.g., quality of sleep, involvement in sports, etc.) on their academics. Within the student population, a significant amount of literature has indicated the importance of sleep and proper attention in academic functioning and success (e.g., Curcio et al., 2006; Henning et al., 2022; Jalali et al., 2020; Okano et al., 2019). This is of particular concern given the levels of inappropriate sleep, in addition to its consequences on attention, reported both in the current study, as well as other contemporary research (Chua et al., 2017; Massar et al., 2019; Mbous et al., 2022), as addressed above.

Beyond the student population

While our study addressed sleep, impulsivity, and interpersonal functioning specifically in the university student population with its specific characteristics (e.g., studying, learning) and lifestyle (e.g., new social circles, sleep-habit changes, dietary changes), the findings may (taking into consideration certain limitations, e.g., socioeconomic status, life events, etc.) also have broader implications on the general population. In this regard, executive functioning, attention, interpersonal relationships, and the impact of sleep on such behaviors, have the potential to significantly influence numerous common day-to-day human behaviors and tasks (e.g., reading, writing, etc.), including in the context of various work settings (e.g., hands-on labor, operation of equipment, etc.) (Brossoit et al., 2019; Litwiller et al., 2017; Pilcher and Morris, 2020). Thus, as is reflected in the literature, it is not just the student population that suffers the consequences resulting from inappropriate/poor sleep. Ultimately, despite the differences that naturally exist across various social environments (e.g., school, workplace, home), there is a fundamental modus operandi in human physiological and behavioral functioning that is impacted by sleep and therefore, in reality, the implications of our findings are likely generalizable well beyond the student population.

Addressing the issue: the need to focus on the problem

As previously mentioned, pharmacological agents can be utilized to address the negative symptoms experienced as a result of poor/inappropriate sleep. However,

these drugs cannot and do not replace the role of sleep as an essential innate physiological behavior. Inappropriate use of pharmacological agents (including in beverages containing caffeine such as, energy drinks, coffee, etc.) may lead to negative repercussions including, but not limited to, an increased propensity for error, including in critical/crucial situations (e.g., surgeon errors, adverse performance and safety outcomes in police officers, etc.) despite the acute relief of the symptoms (Aggarwal et al., 2011; Ogeil et al., 2018). Thus, seeking to relieve symptoms (*reactive* approach) may be necessary when a problem is already present. However, the long-term goal of any approach must be focused on addressing the *root* (fundamental underlying cause) of the issue (e.g., Riera-Sampol et al., 2022).

In the context of our study, impulsive behavior was an important factor in the relationships observed. Impulsive behavior underlies negative mental health and a broad spectrum of psychiatric disorders (e.g., Griffin et al., 2018; Smith et al., 2019; Tangney et al., 2004). In contrast, impulse control (i.e., increasing self-control), including its promotion and utilization in therapy (e.g., CBT), has been previously shown to be of benefit in a broad spectrum of behaviors (Smith et al., 2019; Tangney et al., 2004). Thus, encouraging principled behaviors that promote self-discipline/self-control has the potential to reduce negative (e.g., impulsive) and contribute to positive behaviors across a broad spectrum of life circumstances, including, but not limited to, interpersonal relationships, academics and avoidance of destructive behaviors, such as alcohol abuse (Claver et al., 2020; Rogus, 1985; Shi and Qu, 2022; Tangney et al., 2004).

The necessity for principled behaviors in order to achieve success, including in academia, is not a new concept, remembering that university life reflects, in many ways, a microcosm of society. Self-discipline, through its influence on decision-making, ultimately impacts common daily behaviors, such as sleep, diet and general hygiene (Hershner and O'Brien, 2018; Sertillanges, 1946 (1998)), and requires a consistent effort over time, through potential modifications of behavior, to achieve one's ultimate goal (e.g., improving sleep) (Duckworth et al., 2007; Hagger and Hamilton, 2019; Li and Li, 2021). Such perseverance (sometimes referred to as "grit" in the literature, or "perseverance and passion for long-term goals" (Duckworth et al., 2007) has long term implications, with an ultimate potential outcome of improved overall general and psychological well-being (Duckworth et al., 2007; Lee et al., 2023; Verberg et al., 2019).

Underlying principled behaviors, self-discipline, and perseverance is motivation, which drives personal initiative and, in turn, is dependent on personal autonomy (Cook and Artino, 2016; Patel and Thatcher, 2012). However, given the social nature of humans, and that personal autonomy does not exclude social interaction and community (including, but not limited to, family), but rather includes healthy social relationships while preserving the capacity for self-determination (Ryff, 2014; Vansteenkiste and Ryan, 2013), the cooperation of individuals is necessary in order to maximize the impact of self-discipline. While personal effort is imperative on the side of the individual (e.g., student, employee, etc.) to be self-disciplined (e.g., getting proper sleep, studying, etc.), community support and reinforcement (e.g., in policy-making, in education, by university administration, professors, parents, etc.) is essential. In effect, self-discipline needs to become "everyone's reality" (Rogus, 1985).

Limitations

The primary limitation of our study is that associations with measures of mental health such as depression, anxiety and stress cannot be made given a direct measure of mental health (e.g., DASS-21) was not included. However, the study did investigate impulsivity, which is an underlying characteristic of various mental health disorders (e.g., Chamorro et al., 2012; Moeller et al., 2001) and reflects a dysfunctional corticolimbic dynamic which is documented extensively clinically and in the scientific literature as underlying psychopathology/psychiatric disorders (e.g., Kovner et al., 2019; Spikman et al., 2000). It is predicted, given previous literature (Alonzo et al., 2021; Zou et al., 2020), that had direct mental health measures been included, individuals reporting poor sleep quality (as measured by the PSQI) would have also reported more negative mental health, similar to what was observed with impulsivity. Related, while psychopathologies that have the potential to impact the variables investigated in this study, such as ADHD (Becker et al., 2018; Sodano et al., 2021) or bipolar disorder (Palagini et al., 2019), were not included as exclusion criteria or covariates, this limitation needs to be considered in the context of the multidirectional relationship of the variables involved in sleep, including its relationship to ADHD as previously discussed in Sect. " Interpersonal Functioning, Sleep and Executive Function".

A consideration pertaining to the interpretation of the results and their implications is the necessity to also consider the limitations (which continue to be debated, most especially in the field of psychology) of any research design and the optimal statistical methods utilized. For example, we utilized t-tests to compare sex differences for the PSQI, BIS-11, FIAT-Q-SF subscales individually. While we chose this test because of the fact that each subscale is a separate entity and we were not comparing between the subscales within a specific

scale, the reader needs to consider the potential of an inflated Type-I error rate resulting from this methodology in the interpretation of these results. Additional consideration becomes particularly relevant in relation to the more complex analyses such as mediation analysis. However, while caution is always necessary when implying causation, the reality of the complexity of human behavior and the multidirectional and multicomponent relationships that most investigated human behaviors involve (i.e. the rarity of unidirectional relationships) need to be considered, as well as the consistency and logic of any findings with those of existing research and human experience, which we sought to consider in the discussion of our findings.

Additionally, while our study consisted of a sample size representative of our population, a larger sample size or alternative design (e.g., longitudinal study) could potentially have provided further clarity on certain statistical outcomes that were bordering on significance such as the impulsivity subscales in relation to their potential mediating role. Moreover, while our study included a sample from a single university student population, the findings should be considered in the context of the fundamental consistencies that exist within human behavior across cultures/societies, and the congruity between the findings in our samples and other scientific literature pertaining to university students and the general population. Thus, similar results would be expected in studies investigating other populations, including other university student samples.

An additional point for consideration is that while the scientific literature indicates negative repercussions of COVID-19 on individual's sleep/sleep quality (e.g., Alimoradi et al., 2021; Alqahtani et al., 2022; Ferreira-Souza et al., 2023; Fiorillo et al., 2020; Mandelkorn et al., 2021; Morin and Carrier, 2021; Son et al., 2020), given the data for this study was collected in 2022, our study cannot provide any direct link to COVID-19 measures, although such an impact cannot be totally dismissed, as also reflected in our previous findings (Emmerton et al., 2024). Additionally, given that this was not a longitudinal study, it is also not possible to make comparisons to the pre-COVID-19 time period. Of note, at the time of the survey administration, the dynamics associated with lockdowns, mask mandates, etc. had been substantially relaxed (Abbasi, 2022; Ballotpedia, 2022).

Conclusions

The levels of poor sleep quality and impulsivity reported both in our study and previous literature are of particular concern, given their potential to negatively impact an individual's physiological/physical and psychological well-being, which can ultimately influence behaviors, including interpersonal functioning (as indicated by our findings), with the potential to further impact the well-being of the individual. This is particularly important given the continued deterioration in mental health despite the increased resources being made available. Overall, our findings suggest that sleep quality and its relationship with impulsivity, specifically attentional impulsivity, have the potential to impact an individual's interpersonal functioning.

As appears to be the case in most circumstances in life, in order to achieve overall well-being, when an issue arises, it is ideal that a *long-term* approach that addresses the root of the problem is considered, rather than *solely* targeting, in the short-term, the phenotypic "symptoms" resulting from the primary issue. In regard to the current findings, rather than simply seeking to *minimize the negative consequences* associated with lower interpersonal functioning, it would appear to be more beneficial to *maximize preventative constructive behaviors* (such as improving sleep quality and minimizing impulsivity, i.e., addressing the root of the issue) that build character/virtue and strengthen the individual, including through self-discipline and perseverance.

Abbreviations

PSQI	Pittsburgh Sleep Quality Index
BIS-11	Barratt Impulsiveness Scale Version 11
AttImp	Attentional Impulsiveness
MotImp	Motor Impulsiveness
NpImp	Non-planning Impulsiveness
FIAT-Q-SF	Functional Idiographic Assessment Template—Questionnaire—Short Form
AvdInt	Avoidance of Interpersonal Intimacy
ArgDis	Argumentativeness or Disagreement
ConRec	Connection and Reciprocity
ConAve	Conflict Aversion
EmoExp	Emotional Experience and Expression
ExcExp	Excessive Expressivity

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41606-024-00113-8.

Additional file 1: Supplementary Table 1. Summary of demographic variables

Additional file 2: Supplementary Table 2. Complete results for mediation pathways between sleep quality (PSQI) and interpersonal functioning (FIAT-Q-SF) with impulsivity (BIS-11: AttImp, MotImp, NpImp) as potential mediators. PSQI = Global PSQI; AttImp = Attentional impulsiveness; MotImp = Motor impulsiveness; NpImp = Non-planning impulsiveness; FIAT = Total FIAT-Q-SF

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Authors' contributions

SS supervised the study. BJF and SS contributed to the conception, design and conducting of the study. SS, CC, RWE performed the statistical analyses

and contributed to the writing of the first draft of the manuscript. All authors contributed to the revisions of the manuscript and read and approved the submitted version.

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Availability of data and materials
The data underlying this article will be shared on reasonable request to the corresponding author.

Declarations

Ethics approval and consent to participate
The study involved human participants and was reviewed and approved by the Franciscan University of Steubenville Institutional Review Board (IRB: #2022–4). The participants provided informed consent to participate in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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