The Early-Bird Catches the Worm: An Investigative Study into the Relationship Between Sleep Behaviours and Academic Achievement

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Abstract

Academic achievement is paramount for students, shaping career prospects. The present study aimed to explore the factors impacting academic achievement, specifically focusing on sleep components, chronotype and perceived stress. The student sample ($N = 393$) consisted of 329 females (84%) 51 males (13%) and 11 non-binary individuals (3%). Participants completed an online questionnaire including measures of sleep quality, sleep hygiene, chronotype, stress and academic achievement. The data were analysed using a cross-sectional between-subjects design. Multiple regression analyses revealed that both chronotype and stress significantly predicted academic achievement. Findings suggest that high perceived stress scores, and high morningness scores are associated with high academic achievement. Sleep as a latent variable (comprising sleep quality and sleep hygiene) did not significantly predict academic achievement. These findings underscore the role of sleep behaviour and stress management in academic achievement, offering an avenue for further investigation to determine the underlying mechanisms that determine academic achievement.

Keywords: Academic Achievement, Sleep Hygiene, Sleep Quality, Stress

Academic achievement (AA) is a cornerstone representing a pathway to career success in the lives of university students (Moore, 2019). Research defines AA through standardised test scores, course completion rates, and most commonly Grade Point Average (GPA), reflecting its diverse nature (Dickinson et al., 2015; Seoane et al., 2020). Despite this, GPA is not employed universally, therefore the present study defines AA using an average percentage grade, emulating the objective comparability of GPA (Westrick, 2017). As research considers the multifaceted pressures on students, it is apparent that academic success is not determined solely by intelligence and determination. Instead, achievement is shaped by various factors including wellbeing, motivation, and socio-economic background (Mahdavi et al., 2021; Munir et al., 2023). Meta-analytical research demonstrates the pivotal role of sleep when shaping AA (r = .10; Dewald et al., 2010). Understanding these underlying influences is imperative for devising holistic approaches to support students in navigating the challenges inhibiting AA (Hershner, 2020).

Sleep

Why do we sleep? Sleep is predominantly defined and measured through self-reported hours slept and perceived sleep quality. Though lacking formal definition, the term 'sleep quality' (SQ) encompasses both subjective and objective evaluations of factors contributing to the overall sleep experience, typically including sleep duration, efficiency, wake time, and sleep disturbance (SD). The frequently employed Pittsburgh Sleep Quality Index (PSQI) quantifies SQ based on these parameters. However, objective measures including polysomnography and actigraphy are uncommon due to cost and comparability constraints (Krystal & Edinger, 2008). Poor SQ and SD, increasingly prevalent globally, underscore the essential role of sleep in facilitating vital cognitive processes in conjunction with waking brain function (Killgore, 2010; Walker, 2009). Recognised as a pressing public health concern, SD

contributes to heightened accident rates and decreased efficiency (Philip & Askerstedt, 2006). Research indicates deficits in attention, learning, memory, and emotional reactivity following SD, yet findings diverge regarding its impact on higher-order processes such as decision-making, perception, and executive function (Goel et al, 2009; McCoy & Strecker, 2011). Although studies have demonstrated the cognitive benefits of sleep, a consensus on its implications remains elusive (Ellenbogen, 2005; Walker, 2008). Between-subjects experimental studies provide evidentiary support for sleep-dependent cognitive processing, corroborating the sleep-memory consolidation hypothesis (Ellenbogen, 2005; Siegel, 2001). Further evidence substantiates the bidirectional relationship between SQ and brain activity, indicating reduced attention and learning-related hippocampal activity in sleep-deprived participants during cognitive tasks (Krause et al, 2017; McDermott et al, 2003).

Notably, chronic SD affects approximately 70.6% of university students, with an average sleep duration below eight hours (Lund et al., 2010). Considering the established relationship between sleep and cognitive function, it is unsurprising that research consistently associates poor SQ with decreased AA (Burns et al., 2018; Okano et al., 2019). Empirical evaluations focus heavily on sleep duration and SQ, neglecting numerous influential factors (Musshafen et al., 2021). Studies relating both SQ and duration with behaviour and cognition emphasise their implications for long-term development and AA (Lewin et al., 2017; Ming et al., 2011). In contrast, several studies have reported little to no significance between the variables (Cusick et al., 2018; Elliason et al., 2010). Nevertheless, a recent meta-analysis by Musshafen et al. (2021) corroborated the significant effect between SQ and AA (r = .09). The meta-analysis reported a lack of high-quality publications, with studies relying extensively on self-reported SQ, and inconsistent measurements. Additionally, results highlighted complexities, necessitating consideration of additional sleep constructs, namely: wake time, sleep hygiene (SH) and chronotype (Musshafen et al., 2021). These variables associated with

both SQ and cognition, should be considered to further understand the relationship between sleep and AA (Alfonsi et al., 2020; Cohen-Zion et al., 2018).

Sleep Hygiene on Academic Achievement

Sleep Hygiene (SH) involves behaviours and habits aimed at enhancing both SQ and duration. While definitions vary, SH primarily consists of individual components including, but not limited to, sleep-wake times, environment, exercise, bedtime routine, and stimulant use. However, research lacks consensus on factors defining SH (Irish et al., 2015; Pasquale et al., 2024). While the importance of SH in promoting SQ among students is well-established (r = .40; Ali et al., 2023), a gap persists between knowledge and practice. Many students engaging in disruptive behaviours such as late-night electronic device use, irregular sleep schedules, and excessive alcohol and caffeine consumption (Humphries et al., 2021). These factors are implicated in the relationship between sleep and AA, with 60% of students reporting sleep disturbances and 35% exhibiting irregular sleep-wake patterns (Raley et al., 2016). Research indicates that misconceptions surrounding SH facilitate maladaptive behaviours, with students pulling 'all-nighters' achieving significantly lower grades (Brown et al., 2002; Felix et al., 2017). In comparison, Patrick et al. (2017) reported that SD impaired practical but not cognitive ability. Despite widespread detrimental SH practices, the area remains underexplored in conjunction with AA.

Chronotype on Academic Achievement

Beyond examining SQ and SH, studies propose examining individual differences in chronotype in relation to AA (Hershner, 2020; Musshafen et al., 2021). Chronotype, commonly known as morningness and eveningness or 'early-birds' and 'night-owls', defines a person's preferred sleep-wake schedule based on circadian rhythms and influences both SH and SQ (Roenneberg, 2015; Zhu et al., 2022). While most individuals fall between extreme chronotype dimensions, research consistently shows negative correlations between eveningness and AA

across various domains including SQ and alertness, alongside less-measured factors including attendance and conscientiousness (Hershner, 2020; Tonetti et al., 2015). Early-birds typically exhibit higher AA than night-owls, attributed to the alignment of peak cognitive performance and traditional academic schedules (Eliasson et al., 2009; Zerbini & Merrow, 2017). However, conflicting studies suggest positive correlations between eveningness and cognitive ability (r = .08), despite negative correlations between eveningness and AA (r = .14; Preckel et al., 2011). Although SD may not directly relate to chronotype, external constraints may lead to SD, particularly disadvantaging evening types (Montaruli et al., 2019). Adolescence commonly sees students shift towards eveningness, warranting closer attention to its negative implications (Jankovic et al., 2021; Roeser et al., 2013). Understanding chronotype is critical when informing personalised approaches to improving SH, with long-term implications on SQ and AA (Hershner, 2020).

Stress

Stress, defined as a multifaced response involving biological, physiological, emotional, and cognitive reactions to perceived threat, affects approximately 54% of students annually (O'Hara et al., 2014; Thoits, 2010). Although the relationship between stress and learning is not linear, high stress has been found to reduce engagement, increase risk of substance abuse, and impair AA (Jöels et al., 2006; Khan, 2018). While optimal stress levels can improve attention, studies consistently demonstrate a cyclical relationship between high stress and subsequent deterioration in SQ (Almojali et al., 2017; Taylor et al., 2013). Stress in students is frequently associated with academic dropout, burnout, and declining AA (Pascoe et al., 2019). Findings support Kalmbach et al., (2018)'s theory on sleep reactivity, which poses the notion that stress impacts directly on SQ. The Stress Disparity Model proposed by Heissel et al. (2017) corroborates this, depicting a reciprocal relationship between the hypothalamic-pituitary-adrenal axis stress response, sleep, and AA. However, challenges in measuring the biological

stress response on a large scale, and defining 'optimal' levels of stress, limits research on the interaction (Gardani et al., 2022; Heissel et al., 2017).

The Present Study

Despite extensive research examining students' sleep practices, studies have primarily investigated SQ and duration in relation to AA, overlooking critical factors including chronotype, SH and stress (Musshafen et al., 2021). Moreover, limited high-quality research has explored sleep among university populations outside the U.S, with predominant focus on high school students. When undergraduates are considered, studies often employ clinical or medical student samples, thereby limiting generalisability beyond specific cohorts (Dewald et al., 2010; Seoane et al., 2020). Notably, many studies were excluded from meta-analyses due to unreported values, and unstandardised measures of sleep and chronotype, undermining the validity and generalisability of findings (Musshafen et al., 2021). These limitations represent a motive for further investigation into the relationship between sleep practices (including SQ, SH and chronotype), stress, and AA among university students. Considering this, the present study aims to address these gaps, exploring sleep as a latent variable (comprising SQ and SH) alongside chronotype and stress in relation to AA in university students. More specifically, the study hypothesised, based on frequently reported associations between sleep and cognitive performance, that there would be a statistically significant relationship between sleep as a latent variable (SLV) and AA (Dewald et al., 2010; Musshafen et al., 2021). Additionally, based on prior research implicating sleep-wake cycles and the theory of sleep reactivity in AA, we hypothesised that the relationships between both chronotype and AA, and stress and AA would be statistically significant (Gardani et al., 2022; Hershner, 2020).

Methods

Participants

Out of the initial 508 individuals who accessed the online questionnaire, 115 responses were excluded from the analysis due to missing data or failed attention checks. This left a final sample size of 393 participants, whose ages ranged from 18 to 57 (M = 24, SD = 8.13). G*Power 3.1.9.4 software (Erdfelder et al., 1996) was employed to estimate the sample size required by performing an *a priori* calculation. With a power of ($1 - \beta$) .95 and an α of .05, 119 participants were required to detect a medium sized effect (f^2 = .15) in multiple regression analysis (Kang, 2021). Ethical approval for the study protocol was granted by the lead university. See Table 1 below for a detailed breakdown of sociodemographic characteristics of participants.

Table 1

Sociodemographic Characteristics of Participant Pool

Variable	*N = 393*	*%*
Gender		
Female	329	83.7
Male	51	12.9
Non-Binary	11	2.8
Not Stated	2	0.5
Age	*M* = 24	
Year of Study		
First	85	21.6
Second	109	27.7
Third	123	31.3
Fourth	52	13.2
Program of Study		
Business / Finance	26	6.6
Health Sciences	33	8.4

Humanities	16	4.1
Law / Politics	10	2.5
Social Sciences	291	74
Miscellaneous	17	4.3
Employment		
Full Time	23	5.9
Part Time	194	49.4
Self-Employment	8	2
Unemployed	149	37.9
Unable to Work	10	2.5
Not Stated	9	2.3
Research Participation Status [a]	193	49.1

Note. [a] Reflects the number and percentage of participants answering "yes" to this question.

Materials

Participants completed a series of online questionnaires incorporating standardised measures of SQ, SH, chronotype and stress alongside a series of demographic questions and a measure of AA.

Chronotype

Chronotype was measured using the Morningness Eveningness Questionnaire (MEQ; Horne & Östberg, 1976). The MEQ is widely supported as the most commonly utilised established scale in chronotype assessment, demonstrating validity in measuring both objective and subjective concepts and high internal consistency in reported samples ($\alpha = .85$) (Adan et al., 2012; Di Milia et al., 2013; Panjeh et al., 2020). The scale consists of 19 items assessing individual differences in morningness and eveningness. Responses were given on 4- and 5-point scales using both Likert and time-scale formatted questions and each response was assigned a numerical value based on the chronotype it represents. Examples of these items include "If you have no commitments the next day, what time would you go to bed compared to your usual bedtime?" with '1' being "more than two hours later", and '4' being "seldom or

never later". Items were summed to indicate chronotype (possible range of scores from 16-86). Based on their summed score individuals are categorised: evening type (16-41), intermediate type (42-58) or morning type (59-86). An internal analysis of the MEQ found that it demonstrated good internal consistency in the present sample (α = .87).

Sleep Hygiene

Sleep hygiene (SH) was measured using the Sleep Hygiene Index (SHI; Mastin et al., 2006). The SHI has been utilised frequently within sleep research, and constructs have been supported by positive correlational relationships with diagnostic criteria for inadequate SH (*r* = .48; Mastin et al., 2006). Thirteen items assessed the practice of SH behaviours. Responses were given on a 5-point scale from never (0) to always (4). Examples of these items include "I stay in bed longer than I should 2 or 3 times a week" and "I go to bed feeling stressed, angry, upset or nervous". Items are summed to indicate a level of SH with high scores indicating worse SH (possible range of scores from 0-52). An internal analysis of the SHI found that is demonstrated acceptable internal consistency in the present sample (α = .74), above that found in previous literature (α = .66; Mastin et al., 2006).

Sleep Quality

SQ was measured using the Pittsburgh sleep quality index (PSQI; Buysse et al., 1989). The PSQI has been praised for its comprehensive evaluation of multiple SQ dimensions; the scale allows the researcher to obtain a detailed understanding of overall SQ (Grandner et al., 2006). Ten items assessed SQ. Participants responded on a 4-point scale from no difficulty (0) to severe difficulty (3). Examples of these items include "During the past month, what time have you usually gotten up in the morning" and "How long in minutes has it taken you to fall asleep each night?" Items were summed to form a measure of SQ with high scores indicating worse sleep (possible range of scores from 0-21). Internal analysis of the PSQI found that it

demonstrated an unacceptable internal consistency (α = .64); following investigation removal of components six and seven (use of sleep medication and daytime dysfunction) increased internal consistency in order to reach an acceptable level (α = .70). The retraction of the final two components, rendering the scale PSQI-5, is supported for use in non-clinical samples with internal consistency of the PSQI-5 in tested samples rising from (α = .68) to (α = .78; Zhang et al., 2020).

Stress

Stress was measured using the perceived stress scale (PSS; Cohen et al., 1983). The psychometric properties of the PSS have been established across populations of university students (α = .78; Anwer et al., 2020). Participants responded to 10 items measuring perceived stress on a 5-point scale from never (0) to very often (4). An example of one of these items is "In the last month how often have you felt nervous and stressed". Items were summed to indicate a total measure of perceived stress (possible range of scores from 0-40 with high scores representing high levels of stress). An internal analysis of the PSS found that it exhibited good reliability in the present sample (α = .87).

Study Design and Procedure

A cross-sectional between-subjects design was employed. Participants were recruited through convenience and snowball sampling methods, including physical advertisement posters, and social media posts (Biernacki & Waldorf, 1981). Social media platforms used included Facebook, WhatsApp, and Instagram. Additionally, participants were sourced through the lead university's research participation scheme (RPS), incentivised with course credits for their involvement. The provided link directed participants to a Qualtrics (2024) survey page. Participants were initially presented with an information sheet detailing the study aims and informing them of their ethical rights including anonymity and the right to withdraw. Upon providing consent, participants were instructed to complete a demographic questionnaire

to facilitate the collection of information including age, gender, student status, average grade, employment status and course enrolment. Demographic questions assessed participants, ensuring they met inclusion criteria. Participants who were not currently students or were under 18 years old were excluded from the survey. Additionally, participants were requested to calculate an average percentage grade (based on all assessment feedback received within the preceding six months). Subsequently, participants progressed to complete four scales detailed above: the MEQ, SHI, PSQI and the PSS. An attention check, in the form of an instructed response item, was incorporated within the aforementioned scales; individuals failing this check were excluded from analysis. Each scale took approximately five minutes for completion, resulting in an overall data collection time of approximately 15 minutes per participant. Upon survey completion participants were directed to a short debrief form reiterating the study aims, researcher contact details and further subject materials. The study was open for participation from the 05/02/24 to the 17/03/24.

Data Analysis

Data was exported from Qualtrics (2024), and statistical analyses were run using IBM SPSS statistics [Version 28.0] (IBM Corp, 2021) and JASP [Version 0.18.3] (JASP Team, 2024). Items 4,5,7 and 8 of the PSS were reverse-coded and scale scores were summed across all measures. Data was screened across each observed variable for assumptions of normality using skewness and kurtosis z-scores, histograms, and Shapiro-Wilk tests for each observed variable. All measures met normality criteria. Following visual inspection of boxplots, no significant outliers were detected. Both Levene's ($F(4, 388) = 0.878$, $p = .477$) and Durbin-Watson statistic's ($D = 2.017$, $p = .884$) tested the assumptions of homoscedasticity and independence of errors respectively. VIF values of 1.035, 1.043 and 1.009 indicated minimal multicollinearity (Daoud, 2017; Uyanık & Güler, 2013).

In order to examine both hypotheses, correlation analyses were performed to establish any relationships between independent variables and the dependent variable. Following this, measures of both SQ and SH underwent factor reduction using principal component analysis (PCA). This commonly employed data-driven technique aims to maximize variability and diminish the dimensionality of a dataset, which is particularly valuable due to the shared multiple structures present in each sleep questionnaire (Greenacre et al., 2022; Joliffe & Cadima, 2016). Orthogonal Varimax rotation was then applied to the component matrix, with factor loadings above 0.4 considered significant. This approach provided a novel variable, titled "Sleep Latent Variable" (SLV). Subsequently, a multiple regression analysis was conducted in order to establish the relative strength of SLV, PSS and PSQI in predicting AA. The *p*-value of less than .05 was considered statistically significant for all analyses (Field, 2018).

Results

Examining Relationships Between Variables

Correlation analysis revealed SH (SHI) demonstrated a statistically significant negative correlation with SQ (PSQI) ($r = .385$, $p < .001$). A positive correlation was revealed between SH and chronotype (MEQ) ($r = .579$, $p < .001$). Likewise, a significant negative relationship was identified between SQ and chronotype ($r = .225$, $p < .001$). See descriptive statistics and correlations in Table 2.

Table 2

Descriptive Statistics and Correlations for Study Variables

Variable	*M*	*SD*	1	2	3	4	5
1. Academic Achievement [a]	68.31	8.79	—				
2. PSQI Global Score	5.06	2.52	-.012	—			

3. PSS Global Score	20.19	6.46	-.142**	.320**	—		
4. SHI Global Score	28.46	6.80	.233**	-.385**	-.435**	—	
5. MEQ Global Score	47.56	10.19	.172**	-.225**	-.183**	.579**	—

Note. [a] Values reflect a calculated average percentage grade based on assessment feedback across six months.

** Correlation is significant at the 0.01 level (2-tailed).

Relationship Between Sleep Components

A PCA extracted one component with eigenvalues greater than one, accounting for 69% of the total variance. The component labelled 'Sleep Latent Variable', consists of SQ (PSQI) and SH (SHI). Latent variables were produced by regressing task scores onto the rotated component matrix (see Table 3).

Table 3

Rotated Component Loading on Sleep Measures

Variable	Sleep Latent Variable (SLV)
PSQI Global Score	**.832**
SHI Global Score	**.832**

Note. Bold = Factor loadings > 0.4

Examining Stress and Sleep as Predictors of Academic Achievement

Multiple regression analysis demonstrated that the overall fit of the model was statistically significant as indicated with an *F*-statistic of 6.42 and a *p*-value of less than .001 ($F(3,388) = 6.42$, $p < .001$), suggesting that the model explains a significant portion of the variance in AA. The R^2 value of .047 further illustrates that our model can account for approximately 4.7% of AA variability, highlighting the included predictors' substantial impact. Both MEQ ($b = .13$, $\beta = .15$, $t = 3.01$, $p = .003$) and PSS ($b = -.16$, $\beta = -.12$, $t = -2.39$, $p = .017$)

uniquely contributed to AA. However, SLV did not significantly predict AA (b = -.62, β = .07, t = 1.42, p = .156).

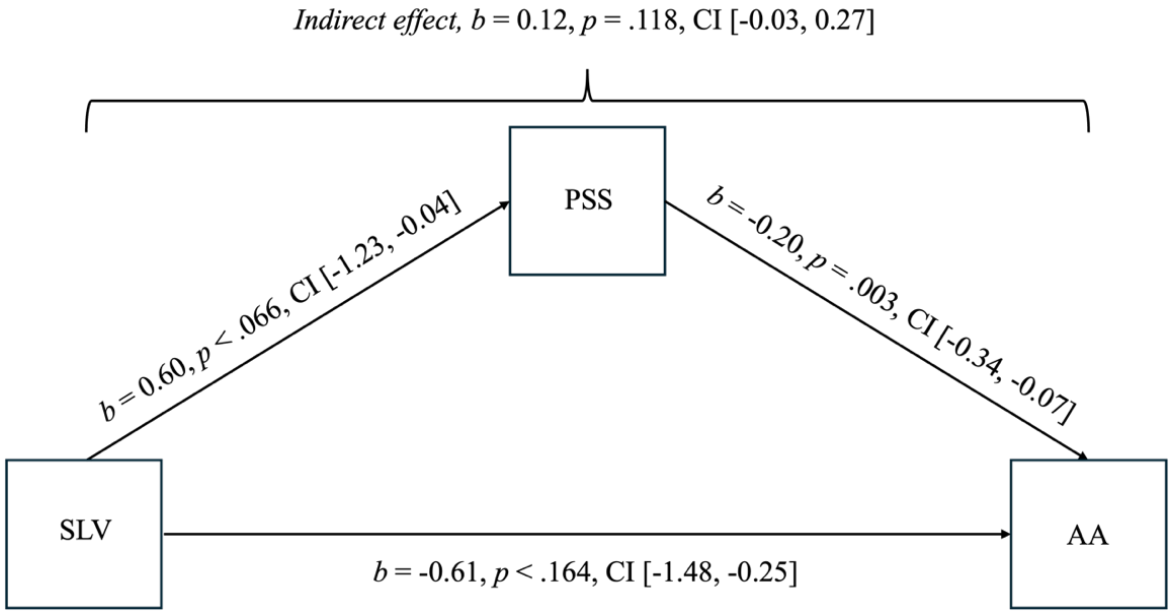
Exploratory Analysis

Exploring the Mediating Role of Stress

Exploratory analysis was conducted post hoc, to explore the non-significant finding of the SLV failing to predict AA. Mediation analysis was conducted to ascertain the process by which the SLV influences AA. Analysis revealed that stress did not mediate the relationship between the SLV and AA (see Figure 1).

Figure 1

Simple Mediation Model: Perceived Stress Mediating the Relationship Between the SLV and AA.



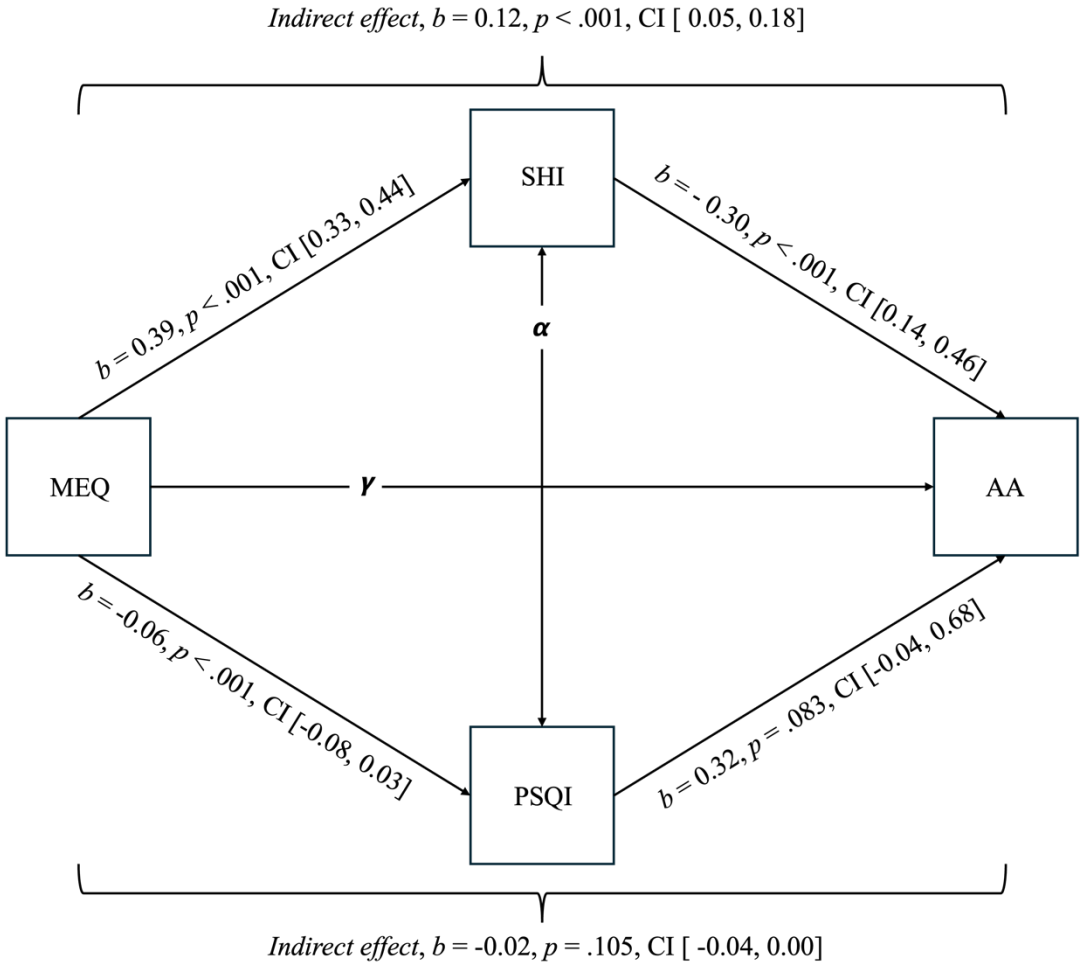
Exploring the Mediating Role of Sleep Hygiene and Sleep Quality

In response to the extensive literature emphasising the significance of examining multiple sleep variables (Musshafen et al., 2021), a further mediation analysis was conducted to elucidate the mechanism by which chronotype impacts AA. Analysis revealed that SH

significantly mediated the relationship between chronotype and AA. However, SQ was not a significant mediating variable influencing the relationship between chronotype and AA. All mediation analyses are depicted in Figure 2.

Figure 2

Parallel Multiple Mediation Model: SH and SQ as Mediators in the Relationship Between Chronotype (MEQ) and AA.



Note. α = the path coefficient between MEQ and AA (b = -4.35, p < .001, CI [-5.76, 2.94]). γ = residual covariances between SHI and PSQI (b = 0.05, p = .344, CI [-0.05, 0.15]).

Discussion

The present study aimed to investigate the relationship between sleep and AA in university students, examining influential factors including SQ, SH, chronotype, and stress.

Specifically, the study aimed to investigate sleep as a latent variable comprising SH and SQ, anticipating a significant relationship with AA. Regression analyses revealed no significant relationship between the SLV and AA; consequently, the null hypothesis was accepted. The study also aimed to explore the relationships between both chronotype and AA, and stress and AA. Regression analyses indicated significant associations between both chronotype and stress with AA; therefore, the null hypothesis was rejected.

Sleep and Academic Achievement

A prerequisite PCA revealed that a single component, labelled 'sleep latent variable' (SLV), comprising SQ and SH, explained a substantial proportion of the variability in sleep-related variables. This suggests that SQ and SH can be considered as integrated components of overall sleep behaviour, providing a foundation for further exploration into the relationship between sleep and AA. However, subsequent regression analyses indicated that SLV was not a significant unique contributor to AA. These findings challenge the prevailing literature, which consistently demonstrated a significant relationship between sleep and AA (Dewald et al., 2010; Okano et al., 2019). The divergence from prior theoretical expectations reinforces the finding that other factors not captured by the SLV such as stress and chronotype, may play a more prominent role in determining AA, highlighting the need for a nuanced understanding of the relationship (Alfonsi et al., 2020; Hershner, 2020). The comprehensive sleep component formed through PCA reinforces the notion, proposed in previous studies, that SQ alone inadequately captures the intricacies of sleep practices (Musshafen et al., 2021). Moreover, employing a large sample drawn from various academic pathways may have mitigated biases inherent in existing research, stemming from the predominantly clinical and medical student-based samples (Seoane et al., 2020).

Chronotype and Academic Achievement

Multiple regression analysis revealed a significant relationship between chronotype and AA. Specifically, individuals categorised as 'early-birds', exhibiting higher levels of morningness, reported significantly higher AA than those high in eveningness. This highlights the pivotal role of chronotype in shaping AA, contributing to the existing evidence base by supporting the impact of individual differences in sleep-wake cycles, on AA (Hershner, 2020). While prior literature implicates SQ in the relationship between chronotype and AA, this association did not hold true in the present sample, with the SLV failing to significantly predict AA (Tonetti et al., 2015). Nevertheless, our findings align with and expand upon existing literature, emphasising the importance of considering chronotype when investigating the relationship between sleep and AA (Eliason et al., 2009). Notably, results support the finding that misalignment of an individual's chronotype with their academic schedule negatively impacts AA (Hershner, 2020; c.f., Preckel et al., 2011). Variability in the relationship between the SLV and chronotype predicting AA may stem from individual differences in adaptation to pre-defined schedules, alongside divergence in coping mechanisms (Montaruli et al., 2019).

Stress and Academic Achievement

Finally, multiple regression analysis revealed a significant relationship between perceived stress and AA. Specifically, individuals with higher scores on the PSQI reported significantly lower average grades, indicating that increased stress negatively affects AA. These findings corroborate the Stress Disparity Model, proposing a relationship between stress and AA, mediated by sleep reactivity; further supported by the significant influence of chronotype (Heissel et al., 2017). However, the model posits that this relationship is primarily influenced by the deterioration of SQ due to stress, a notion that this study cannot corroborate. Therefore, rather than solely attributing the present findings to sleep reactivity, it is conceivable that in the present sample, interacting factors including maladaptive coping mechanisms,

wellbeing, motivation, or absenteeism influenced AA beyond the scope of the SLV (Khan, 2018; Pascoe et al., 2019).

Exploratory Findings

The Mediating Role of Stress

Based on the preliminary findings, exploratory analysis investigated the mediating role of stress on the relationship between SLV and AA. Mediation analyses revealed no significant effect, reinforcing the conclusion that in the present sample, sleep reactivity did not significantly influence AA, thereby corroborating the earlier statement that further variables not captured in the present study may explain the relationship between stress and AA (Khan, 2018; Pascoe et al., 2019).

The Mediating Roles of Sleep Hygiene and Sleep Quality

Additional exploratory analysis considered both SH and PSQI as mediators in the relationship between chronotype and AA. Analysis revealed that SH was a significant mediator, whereas PSQI was not. Furthermore, with SH as a mediator, the direct relationship between chronotype and AA was no longer significant. These findings align with previous research emphasising the importance of SH practices, such as consistent sleep schedules and positive sleep environments, on cognitive performance and AA (Raley et al., 2016; Zhu et al., 2022). The significant mediating role of SH in this study underscores its relevance within the context of chronotype and AA (Hershner, 2020). These findings, alongside the initial hypothesis testing, truly highlight the complexity of the relationship between sleep and AA.

Applied Implications and Future Directions

The findings underscore the importance of measuring multiple sleep variables, including chronotype and SH, for a comprehensive understanding of the relationship between sleep and AA. Exploring these factors alongside individual differences, including attendance,

motivation, socioeconomic status, wellbeing, and cognitive function, may deepen researchers' understanding of the interacting variables (Husing et al., 2016; Klapp et al., 2023). Investigating differences in coping mechanisms may shed light on how SH mediates the relationship between chronotype and AA, while SQ does not. For example, students who seek social support may manage stress and exhibit healthy SH practices, resulting in fewer SDs regardless of chronotype (Montaruli et al., 2024). Future research might adopt an experimental design, employing polysomnography and actigraphy to measure sleep and chronotype, moving beyond the self-report measures overwhelming existing literature (Von Shantz & Knutson, 2024). Furthermore, utilising an objective measure of AA, such as standardised tests or course completion rates, could enhance accuracy and generalisability of findings (Musshafen et al., 2021; Tonetti et al., 2015).

Considering the broader context, policymakers must consider the diverse factors affecting AA and how educational policy changes may enhance AA. Specifically, flexibility in academic schedules, integrating chrono-psychological aspects into scheduling practices, and maximising online learning opportunities post-pandemic have positively influenced AA (Montaruli et al., 2019; Preckel et al., 2011). Through introducing innovative approaches and technological advancements, leveraging platforms to tailor experiences to individual needs, policymakers can cultivate an adaptive environment conducive to fostering academic success across diverse populations (Horzum et al., 2014; Luo et al., 2017). It is imperative that students are sufficiently educated on the impact of maladaptive SH practices. Improving students' understanding surrounding healthy habits, such as regular sleep schedules, maintenance of attention (Sharpe and Hale, 2023), and stimulant avoidance will contribute to habitual change, subsequently improving AA (Humphries et al., 2021).

Conclusion

The present study intended to address key limitations in the current literature regarding sleep and AA. Employing PCA, a comprehensive sleep measure was formed, facilitating simultaneous examination of AA in relation to both SQ and SH. Additionally, analyses considered chronotype and stress as predictors of AA. The primary findings revealed that while sleep did not significantly predict AA, both chronotype and stress were significant predictors. Specifically, high levels of stress and eveningness were associated with a significant decrease in average grade. These findings support the importance of considering individual differences in sleep behaviours for measuring SQ, despite refuting the notion of a linear relationship between SQ and AA. Exploratory findings demonstrated the mediating impact of SH practices on the relationship between chronotype and AA, indicating that the relationship between sleep and AA could be attributed to individual differences in coping mechanisms. These findings emphasise the need to improve students' education surrounding SH and suggest implications for educational policymakers, highlighting the value of flexible academic schedules and innovative teaching approaches in cultivating an environment conducive to academic success. Overall, the study underscores the multifaceted nature of AA, the importance of a holistic approach to measuring sleep, and the necessity for adaptive educational environments.

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