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Too Pressured to Sleep? Exploring the Role of Study Motivation, Test Anxiety and Procrastination in University Students' Sleep Patterns During Exam Periods

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ABSTRACT

During exams students are prone to disrupted sleep. The present two-wave longitudinal study examines the interplay between study motivation, test anxiety, academic procrastination, and sleep among 121 university students (78.5% female; *M*age = 21.69, SD = 1.39). To estimate changes when approaching exams, participants completed surveys in the month preceding and during exams. Latent change models showed mean-level increases in controlled motivation, test anxiety, and poor sleep quality, while procrastination decreased. Structural models revealed strong concurrent and longitudinal links between controlled motivation and both test anxiety and procrastination. Procrastination was mainly associated with decreased sleep hygiene, while test anxiety was robustly linked to decreased sleep quality. Indirect effects from controlled motivation to poor sleep quality through test anxiety were significant. Autonomous motivation acted as a buffer against sleep problems. Findings underscore the importance of interventions targeting motivation quality, especially by minimising controlled motivation, to mitigate sleep problems during exams.

1 | Introduction

For many emerging adults, starting university marks a period of substantial challenge and change. Students adopt new social roles, explore new life paths, and have to independently meet academic demands (Murray and Arnett 2018). As a result, transitioning to university often brings increased stress (Bewick et al. 2010). Worries about academic performance and pressure to succeed make the top two concerns (Tholen et al. 2022). During exams in particular, these concerns can culminate into increases in mental strain (Yang et al. 2020). Similar shifts have been observed regarding university students' sleep patterns. The prevalence of sleep disturbance in student populations is remarkably high, with up to 60% experiencing poor sleep quality (Lund et al. 2010) and 40% reporting 6 h or less sleep per night (Peltzer and Pengpid 2015). Sleep tends to worsen in periods with high academic demands (Gardani et al. 2022), with a peak occurring in the weeks leading up to final exams (Ahrberg et al. 2012). This trend is worrisome due to the well-documented connection between poor sleep and mental distress (Becker et al. 2018), as well as its negative effects on attention, higher-order thinking, and memory (Curcio et al. 2006). As a result, poor sleep during exams can hinder effective studying and academic success.

Identifying psychological factors involved in poor sleep is needed to inform targeted interventions to support healthy sleep during high-stress periods like exams (Bouloukaki et al. 2023). Few studies have identified factors contributing to university students' sleep during exams. According to *Self-Determination Theory* (SDT; Ryan and Deci 2017) high-pressure academic environments disrupt the quality of students' motivation. High-pressure situations such as exams, coincide with a tendency for controlled motivation to dominate over autonomous motivation (Ryan and Deci 2017). This motivational shift may help to explain students' vulnerability for heightened test anxiety and procrastination, which are negatively associated with students' sleep (Steel et al. 2020).

The present two-wave longitudinal study aims to examine the role of motivation in university students' shifts in sleep during exams. As shown in Figure 1, (changes in) the quality of university students' academic motivation from a period of preparing for exams to an actual exam period were examined in relation to (changes in) students' levels of test anxiety and procrastination, which, in turn is expected to relate to sleep.

1.1 | Exam-Driven Shifts in the Quality of Study Motivation

Students report a wide range of reasons for attending classes, learning, and studying for their exams. The quality of students' motivation to study plays an essential role in shaping their daily experiences and academic success (Vansteenkiste et al. 2006). Within SDT (Ryan and Deci 2017), a broad theory on human development and motivation, different controlled and autonomously driven types of study motivation are distinguished (Ryan and Deci 2020). *Autonomous* types of motivation are characterised by a strong sense of freedom and volition, often referred to as self-determined motivation because actions and thoughts stem from the individual's authentic self, rather than being imposed by external forces or pressures. For example, students put effort into their academic work because they perceive it as meaningful and consistent with their personal values and life goals (identified regulation) or because they are genuinely interested in the learning material (intrinsic regulation). On the other hand, *controlled motivation* refers to feeling pressured to act, often driven by a sense of obligation or external demands rather than genuine choice. This pressure can come from external sources, such as rewards or punishments (external regulation), or internal sources, like feelings of guilt, shame, or the need to protect one's self-esteem (introjected regulation). When there is a lack of self-determination, *amotivation* takes over. This happens when students feel like their studies are pointless or when they become discouraged and believe their efforts do not lead to success or meaningful results (Ryan and Deci 2020).

The distinction between different forms of self-determined motivation has been found to be crucial, as meta-analyses show that study motivation driven by greater autonomy relates to deeper and sustained engagement, student performance and improved subjective well-being, while controlled motivation and (more strongly) amotivation are negatively associated with well-being and performance (Howard et al. 2021; Ryan 2023). More specifically, in university students, autonomous motivation is a key predictor of behavioural persistence (Vallerand and Blssonnette 1992) and student engagement (Azila-Gbettor et al. 2021), whereas controlled motivation relates to stress (Reeve and Tseng 2011), depressive symptoms (Holding et al. 2021), and drop-out intentions (Jeno et al. 2018). Amotivation is negatively related to academic competence and performance (Legault et al. 2006).

Rather than static, the type of motivation is known to vary as a function of contextual features, including course content and style of a lecturer (Vermote et al. 2020). Evaluative contexts, such as grading, high-stakes testing, and exams, often lead to a shift from autonomous motivation to controlled motivation and amotivation (Krijgsman et al. 2017), meaning that students feel increased pressure and a sense of obligation to study, rather than perceiving learning as personally valuable or intrinsically interesting. This occurs because being tested or graded during learning activities holds the risk of undermining self-endorsed, autonomous reasons for learning (Ryan and Deci 2017). Research shows that, if students anticipated a test (i.e., external pressure) following a learning task, they found the study material less inherently engaging, a key component of autonomous motivation, compared to those not expecting tests (Benware and Deci 1984). Another study found that university students performed better on exams when professors used practice quizzes (informative and non-pressuring) instead of graded ones, which tend to trigger controlled study motivation (Wickline and Spektor 2011). Since exam periods in higher education—a series of assessments at the end of an academic semester within a

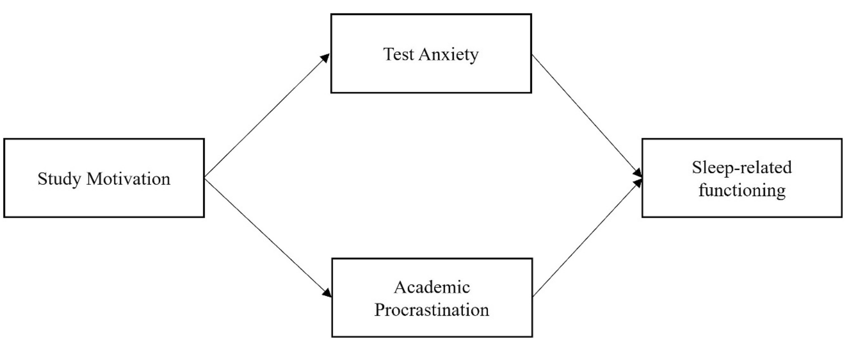

FIGURE 1 | Theoretical model of study hypotheses.

short timeframe—are among the most stressful evaluations (Zeidner 2007), shifts toward more controlled motivation are expected, with some students also becoming amotivated (Krijgsman et al. 2017). Examining such shifts in motivation during exams is crucial, as autonomous motivation is associated with greater perseverance and deeper learning (Howard et al. 2021), both of which are essential for success during exam periods. Therefore, the first aim of the present study is to descriptively examine shifts in autonomous, controlled and amotivation among university students from the period of exam preparation to an actual exam period. In a second objective, we hypothesise that increases in controlled and amotivation relative to autonomous motivation might help to explain the deterioration university students' sleep-related functioning leading up to exams.

1.2 | Test Anxiety and Academic Procrastination

Test anxiety and procrastination typically arise in the face of exams (Hamilton et al. 2021) and are likely to underly the relationship between study motivation and sleep. *Test anxiety* refers to fear or worry experienced during evaluations (Zeidner 2007). Prevalence rates go up to 22% in primary and secondary education (Putwain and Daly 2014) and peak in university students (c. a. 38%; Gerwing et al. 2015). *Academic procrastination* is the tendency to delay or postpone tasks like studying or completing assignments despite knowing the negative consequences (Tao et al. 2021). It reflects failed self-regulation, where students struggle to prioritise long-term goals over immediate gratifications (Zhang et al. 2018). Many students want to complete academic tasks yet encounter challenges in following through, with as many as 48% frequently procrastinating (He 2017).

1.2.1 | Relation to Study Motivation

Previous studies with pupils found amotivation and autonomous types of motivation to be, respectively, positively and negatively related to test anxiety (Çelik and Yıldırım 2019). Among Chinese adolescents in a language course, controlled and autonomous motivation were respectively positively and negatively linked to test anxiety (Vansteenkiste et al. 2005). Autonomous motivation is also negatively related to academic procrastination (Mouratidis et al. 2017). Studies using a person-centred approach confirm that students reporting both high autonomous and low controlled motivation were least susceptible for both test anxiety and procrastination (Vansteenkiste et al. 2009). Collectively, these findings show that, while autonomous motivation goes hand-in-hand with lower test anxiety and procrastination, controlled motivation and amotivation relate positively to both, with controlled motivation showing a particularly strong link to test anxiety. To date, no studies have examined how pre-exam study motivation and its changes relate to changes in test anxiety and academic procrastination. Based on available cross-sectional findings, we hypothesise that students with higher levels or increases in controlled motivation will be most vulnerable to rising test anxiety, as the heightened ego-involvement characteristic of controlled motivation may amplify concerns and anxiety when students come closer to the stressor (Ryan et al. 1991). Conversely, amotivation is expected to increase procrastination during exam periods, as students may withdraw effort and delay studying. In contrast, students with high or increasing autonomous motivation are likely to be best protected against rising test anxiety and procrastination.

1.2.2 | Relation to Sleep-Related Functioning

While the link between general anxiety and sleep is well-established, few studies have specifically examined the impact of test anxiety (Alvaro et al. 2013), and even fewer have explored the role of academic procrastination in sleep. Some research shows that heightened test anxiety in university students during exam preparations related to poorer sleep quality (Hamilton et al. 2021). Nevertheless, there remains uncertainty about how test anxiety and sleep evolve over the longer period leading up to exams. A consideration of this longer timeframe is important because interventions implemented shortly before exams may prove less effective compared to the timely use of preventive measures throughout the academic semester (Huntley et al. 2019). With regard to procrastination, some research found that chronic procrastinators experience poor sleep quality, shorter sleep duration, and more daytime sleepiness (Sirois et al. 2015). A large-scale study found that procrastination relates to social jetlag (i.e., misalignment of circadian rhythm and social/work schedules), shorter sleep duration, and worse sleep quality in youth (Li et al. 2020). One study using momentary assessments in university students found no link between daily procrastination and sleep (Gort et al. 2020). Procrastination may particularly affect sleep as deadlines approach, such as during exam periods, when students compensate for earlier delays by staying up late. This highlights the need for research examining procrastination's impact on sleep during exam periods.

Although test anxiety and academic procrastination are risk factors for poor sleep as exams approach, their unique and combined contribution have not been examined. Previous research primarily focused on interindividual differences, overlooking within-person changes. Based on the findings reviewed above, we hypothesise that students with high levels of or increases in test anxiety and procrastination are more vulnerable for deterioration in sleep patterns during exams. Given the established link between general anxiety, sleep duration, and sleep quality, we hypothesise test anxiety to have the strongest association with these sleep variables. In contrast, procrastination is hypothesised to be more related to sleep hygiene, as students who delay academic tasks may also engage in poor bedtime routines, such as using screens late at night or irregular sleep schedules. Moreover, the study aimed to test an integrated model presented in Figure 1, namely testing the sequence from study motivation to sleep related functioning through test anxiety and procrastination (mediation model).

1.3 | The Present Study

In this two-wave longitudinal study, we examine changes in university students' study motivation, test anxiety, academic procrastination, and sleep patterns in the month leading up to and during exams. By using Latent Change Modelling (LCM), we will estimate both individual differences in students' baseline levels of these study variables and their intra-individual changes from exam preparation to exams. Additionally, LCM allows us to examine level-to-change associations, providing insights into how initial motivation levels at T1 drive changes in test anxiety, procrastination, and sleep outcomes over time. Our four hypotheses are structured around two key objectives.

1.3.1 | Objective 1: Descriptive and Correlated Patterns of Change

Hypothesis 1. *Changes in study variables during exams. We first investigate how students' study-related experiences shift over time (Hypothesis 1). Specifically, students' sleep patterns—measured by sleep quality, sleep duration and efficiency, and sleep hygiene—are expected to deteriorate as exams approach. Meanwhile, study motivation is anticipated to shift towards less autonomous regulation, with an increase in controlled motivation and amotivation. Test anxiety is expected to increase, while the trajectory of academic procrastination is less predictable. While exams may encourage students to increase effort and reduce procrastination, rising pressure could also lead to procrastination as a coping mechanism.*

Hypothesis 2. *The role of study motivation in test anxiety and procrastination. Our second aim is to examine how study motivation relates to test anxiety and procrastination across three levels of analysis: level-to-level, change-to-change, and level-to-change (Hypothesis 2). Controlled motivation is expected to be positively related to test anxiety. Amotivation is expected to be positively related to procrastination. Autonomous motivation is expected to be negatively related to both test anxiety and procrastination.*

Hypothesis 3. *Associations between test anxiety, procrastination, and sleep. The third set of hypotheses examines how test anxiety and procrastination relate to students' sleep patterns across all three levels of analysis. Test anxiety and academic procrastination are expected to be associated with worse sleep patterns. Test anxiety is expected to relate especially to shorter sleep duration and lower sleep quality. Procrastination is expected to more strongly relate to poor sleep hygiene.*

1.4 | Objective 2: Testing an Integrated Model

Hypothesis 4. *The indirect role of test anxiety and procrastination. Finally, we test the indirect effects of test anxiety and procrastination in linking motivation to sleep-related outcomes (Figure 1). Individual differences and changes in sleep quality and sleep duration are expected to be primarily driven by test anxiety and controlled motivation. Individual differences and changes in sleep hygiene are expected to be primarily driven by procrastination and amotivation. Autonomous motivation is expected to be indirectly related to better sleep outcomes through lower test anxiety and procrastination.*

2 | Methods

2.1 | Procedure and Participants

Data was collected as part of a PhD project at the Department of Developmental Personality and Social Psychology at Ghent University. A subset of the data was published in a previous study (Campbell et al. 2018). Students were recruited and received information on the study requirements through an online learning platform. The link to the first questionnaire was distributed in the beginning of May. Participants were instructed to complete questionnaire at the end of the week or on Monday at the latest. The link to the second questionnaire was sent in the beginning of June, but participants were asked to fill out the questionnaire at the end of the week in which they had the highest number of exams. The interval between the first and second measurement was 24.34 days (SD = 6.92). Reminders were sent throughout the study if participants had not yet completed the questionnaire. The study complies with the ethical protocols outlined by the Ethical Committee of the Faculty of Psychology at the host university. An informed consent was signed by all participants. Each participant was assigned a unique code to merge the data of both waves so that their anonymity was guaranteed throughout the entire study. The study design and its analysis were not pre-registered. Materials and analysis code for this study are available by emailing the corresponding author.

Because the unique design and data analytic approach and because we could not locate similar previous studies, we were unable to use effect sizes from prior research to perform an a priori power analysis (Levine and Ensom 2001). The sample consisted of 121 Belgian students (86% university; 14% college university). The male/female ratio was 21.4%/78.5% with a mean age of 21.69 (SD = 1.39, range 19–25). On average, participants had 5.84 exams (SD = 2.39, range 2–13). The majority of participants in the sample (95%) did not cohabit with a romantic partner. Of all participants, 108 took part in both waves (89%). Little's MCAR was non-significant ($p = 0.094$; $\chi 2 = 68.02$, df = 303, normed $\chi 2$ of 0.22), indicating data were likely to be missing completely at random. Consequently, Full Information Maximum Likelihood (FIML) was used to handle missing data in SEM (R. J. A. Little and Rubin 1989). No data was excluded from the analyses.

2.2 | Measures

2.2.1 | Study Motivation

A Dutch version (Vansteenkiste et al. 2009) of the Self-Regulation Questionnaire (SRQ; Ryan and Connell 1989) was used to examine participants' study motivation with respect to the preceding week. The scale consists of 20 items capturing potential reasons to study. Participants reported their agreement on a five-point Likert scale ranging from 1 ('*Not at all important*') to 5 ('*Very important*'). Autonomous motivation was measured with eight items (e.g. 'I am motivated to study because I find studying very interesting') resulting in a good internal consistency at both measurement occasions

($\alpha_{pre} = 0.88$; $\alpha_{exam} = 0.79$). The subscale of controlled motivation consisted of eight items (e.g. 'I am motivated to study because I am supposed to') with values for Cronbach's alpha of $\alpha_{pre} = 0.65$ and $\alpha_{exam} = 0.77$. Four items were used to measure amotivation (e.g., 'I don't see why I'm studying and, frankly, I don't worry about it') which demonstrated good internal consistency ($\alpha_{pre} = 0.88$, $\alpha_{exam} = 0.91$).

2.3 | Test Anxiety and Academic Procrastinations

Participants' test anxiety and procrastination were assessed using subscales from the Dutch version of the Learning and Study Strategies Inventory (LASSI; Weinstein and Palmer 2002). Subscales for test anxiety and academic procrastination consisted of eight (e.g. 'I worried that my school career might be compromised') and ten (e.g. 'I didn't study at the times I actually planned to') items, respectively. Participants rated the items on a 5-point Likert scale ranging from 1 ('*Does not apply to me at all*') to 5 ('*Completely applicable to me*'). Cronbach's alpha values for test anxiety ($\alpha_{pre} = 0.83$, $\alpha_{exam} = 0.77$) and for academic procrastination ($\alpha_{pre} = 0.91$, $\alpha_{exam} = 0.94$) pointed out very good reliability.

2.3.1 | Sleep-Related Functioning

2.3.1.1 | Sleep Quality and Sleep Duration and Efficiency. The same test battery as outlined in Campbell et al. (2015) was used. This included the all seven components of the Pittsburgh Sleep Quality Index (PSQI; Buysse et al. 1989) and the insomnia subscale from the Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al. 2007). The time frame of each questionnaire was adjusted to evaluate sleep patterns over the preceding week. To validate the factor structure established in Campbell et al. (2015), we conducted a Principal Component Analysis (PCA), indicating a factor structure of two separate factors (see Supplementary Analyses; see also Campbell et al. 2018). Hereby, we deviate from the traditional way of using the PSQI (for more information see Supplementary file).

The first factor was labelled as poor sleep quality, which constituted of five indicators, namely poor subjective quality (1 item), sleep latency (2 items), sleep disturbances (9 items) and sleep medication use (1 item) from the PSQI (Buysse et al. 1989) and the insomnia subscale from the IDAS ('I woke up frequently throughout the night'; 6 items; Watson et al. 2007). The insomnia items ($\alpha_{pre} = 0.82$, $\alpha_{exam} = 0.89$) were rated on a 5-point Likert scale ranging from 1 ('*not at all*') to 5 ('*very much so*') and the sleep cognitions ($\alpha_{pre} = 0.78$, $\alpha_{exam} = 0.82$) were rated on an event-frequency scale ranging from 0 ('*Not experienced during the past week*') to 3 ('*Experienced three or more times*'). To create the composite score of poor sleep quality, all indicators were standardized and an average score was calculated.

In the PCA, two items from the PSQI (Buysse et al. 1989), namely sleep duration and sleep efficiency (i.e., the ratio of total sleep time to time in bed) were indicated as a separate factor. Those components were averaged into a composite score to measure sleep duration and efficiency. We labelled this factor as sleep duration and efficiency.

2.3.1.2 | Sleep Hygiene. Additionally, because we were interested in sleep hygiene during exams, we also assessed the Sleep Hygiene Index (SHI; Mastin et al. 2006). The SHI (Mastin et al. 2006) consisted of 13 items ('The time I went to bed differed from day to day') rated on a five-point Likert Scale ('*Never*' to '*Always*'). The internal consistency was $\alpha_{pre} = 0.61$ and $\alpha_{exam} = 0.65$, similar to prior work on students (Mastin et al. 2006).

2.4 | Play of Analysis

To examine differences in participants' initial levels (i.e., latent intercepts or baseline levels) of study motivation, test anxiety, procrastination, and sleep, as well as individual changes (i.e., increases or decreases) in these variables from the first measurement (before exams) to the second measurement (during exams), we used Latent Change Modelling (LCM; Hertzog and Nesselroade 2003). LCMs include latent variables for the intercept (i.e., level) and slope (i.e., change over time) of all study variables, representing between- and within person variance, respectively (Beyers and Goossens 2007). Analyses were performed in Mplus 8.11 (Muthén and Muthén 2017) with FIML estimation. The comparative fit index (CFI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA) were employed to evaluate the model fit. An acceptable fit was indicated by CFI values of 0.90 or above, SRMR values of 0.08 or below, and RMSEA values of 0.06 or below (Hu and Bentler 1999; Kline 2005).

First, for each variable a longitudinal measurement model was created to define the latent variables. Following recommendations by Bagozzi and Edwards (1998), parcels were used. Each latent variable was represented by two parcels combining stronger loading items with weaker loading items (T. D. Little et al. 2002). Items with poor factor loadings on one or both measurement occasions were excluded from the analyses. In line with previous research (Beyers and Goossens 2007) and statistical guidelines (Hoshino and Bentler 2011), to avoid model complexity latent factor scores of the univariate models were saved and used in the subsequent models to examine structural relationships between levels and changes across time.

Second, univariate latent change models (LCMs) were estimated for each study variable separately, yielding four key parameters: (1) the latent mean level, which represents the average score for a variable across all participants at the first measurement occasion, before any change has occurred; (2) the degree of mean-level change, reflecting the average change from the first to the second measurement occasion across all participants; (3) the variance of the mean levels, which captures the between-participant variability at the initial time point; and (4) the variance of the mean-level change, indicating the heterogeneity in change across participants. It is important to assess whether both the mean levels and mean-level changes show significant variance, as this is essential for further analyses of the structural relationships between variables (Beyers and Goossens 2007).

Then, structural LCMs were used to estimate associations between the latent level and change factors of the variables (Hertzog and Nesselroade 2003). By modelling level-to-level associations, we tested whether interindividual differences in the baseline levels of study motivation would relate to baseline levels of test anxiety and academic procrastination, which in turn would relate to levels of the sleep-related outcomes. By modelling change-to-change associations, we examined correlated intra-individual changes between study motivation, procrastination, test anxiety, and sleep-related outcomes. We also included level-to-change associations, namely: paths from baseline levels of study motivation to changes in test anxiety and procrastination, from baseline levels in test anxiety and procrastination to change in sleep-related outcomes, and paths from baseline study motivation to changes in sleep-related outcomes. The change of each variable was also regressed on the level of that same variable (e.g., change of controlled motivation was regressed on the level in controlled motivation) to ensure that the change parameters would represent pure estimations of intra-individual change. Third, we formally tested an integrated model with intervening pathways by specifying indirect paths in Mplus, thereby testing the indirect paths from each predictor to each outcome, through both intervening variables. To ensure robust estimation of these indirect effects, we employed bootstrapping (Muthén and Muthén 1998–2004; Preacher and Hayes 2004), which allows calculations of confidence intervals without assuming normality of the indirect effect distribution. These paths were again tested at the three levels of analysis (i.e., level-to-level, change-to-change, and level-to-change).

3 | Results

3.1 | Preliminary Analyses

3.1.1 | Descriptive Statistics and Correlations

Means, standard deviations, and correlations between study variables at both waves are presented in Table 1. All rank-order stability coefficients were significant, ranging from 0.44 to 0.76. Controlled motivation and amotivation correlated positively with test anxiety and academic procrastination. Autonomous motivation only displayed a negative correlation with academic procrastination at the first measurement occasion. In turn, test anxiety and academic procrastination were negatively correlated with the three sleep-related outcomes in 10 out of 12 cases (two predictors by three outcomes by two waves).

3.2 | Background Variables

Using Multivariate Covariance Analysis, associations were examined between background variables (age, gender, marital status, university type, and number of exams) and study variables. Gender, marital status, and university type were entered as factors, age and number of exams as covariates, and test anxiety, academic procrastination, and sleep variables as dependent variables. At both waves, participants' gender yielded a significant multivariate main effect ($F(5, 88) = 3.11$, $p = 0.012$ at T1; $F(5, 80) = 4.52$, $p = 0.001$ at T2). Male students ($M = 3.53/3.43$ at T1 and T2, respectively) reported significantly more procrastination compared to female students ($M = 2.92/2.62$ at T1 and T2, respectively) both during the preparation ($F(1,92) = 7.99$, $p = 0.006$) and exam period ($F(1,92) = 6.45$, $p = 0.013$). During the preparation period, males ($M = 3.36$) were found to sleep less compared to female students ($M = 3.64$) ($F(1,92) = 4.369$, $p = 0.039$). Other background variables did not yield a significant multivariate effect. Only gender was included as a control variable in the main analyses.

3.3 | Primary Analysis: Latent Change Models

To avoid overparameterisation, three separate measurement models were constructed for sleep quality, sleep duration and efficiency, and sleep hygiene entering all predictors and intervening variables simultaneously. All models showed adequate fit. Comparing unconstrained with constrained models, measurement invariance across both waves was checked. In the unconstrained models, all factor loadings were estimated freely, whereas in the constrained model factor loadings of the parcels at T1 and T2 were set to be equal. Model comparison between unconstrained and constrained models in terms of Chi-Square values showed that both models did not differ significantly (sleep quality, $p = 0.403$; sleep duration and efficiency, $p = 0.670$; sleep hygiene, $p = 0.317$), implying temporal measurement invariance and equal meaning of the latent variables at both waves.

3.3.1 | Objective 1. Descriptive Patterns of Change

Hypothesis 1. *Changes in study variables during exams. To examine Hypothesis 1, we estimated univariate LCMs for all the study variables. Results and fit indices of each model are outlined in Table 2. All latent mean levels, indicating the average scores of the study variables in the before examination measurement occasion, were significant and showed significant variance. Regarding the mean-level change scores, which represent the average change from before to during exams across participants, only four variables showed a significant change. Participants displayed mean-level increases in poor sleep quality, test anxiety, and controlled motivation from pre-exam to exam period. By contrast, academic procrastination declined on average and no significant mean-level changes for sleep hygiene, sleep duration and efficiency autonomous motivation, and amotivation were found. All level and change parameters showed significant variance, indicating substantial heterogeneity in both baseline levels and rates of intra-individual change, except for sleep duration and efficiency. Specifically, no significant variance was found in the change of the sleep duration and efficiency component, which precluded the computation of structural models for this variable.*

Hypothesis 2. *The role of study motivation in test anxiety and procrastination. A separate model was tested for sleep quality (before slash) and sleep hygiene (after slash); however, as similar*

TABLE 1 | Descriptives and correlations between study motivation, test anxiety, procrastination and sleep.

	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Preparation phase																		
1. Autonomous motivation	3.23	0.70	—															
2. Controlled motivation	2.75	0.67	0.06	—														
3. Amotivation	1.30	0.59	−0.32***	0.19*	—													
4. Test anxiety	2.38	0.73	0.04	0.42***	0.28**	—												
5. Procrastination	3.05	0.97	−0.20*	0.24**	0.35***	0.43***	—											
6. Poor sleep quality	0.00	0.69	0.00	0.30**	0.16	0.46***	0.27**	—										
7. Sleep duration and efficiency	3.59	0.57	0.09	−0.08	−0.18	−0.15	−0.20*	−0.44***	—									
8. Sleep hygiene	48.61	5.57	0.03	−0.16	−0.25**	−0.38***	−0.44***	−0.49***	0.31**	—								
Examination phase																		
9. Autonomous motivation	3.30	0.60	**0.69***	0.1	−0.21*	0.03	−0.06	0.08	0.06	−0.09	—							
10. Controlled motivation	2.70	0.64	0.02	**0.64***	0.28**	0.45***	0.32***	0.41***	−0.162	−0.37***	0.24*	—						
11. Amotivation	1.32	0.61	−0.18	0.15	**0.73***	0.33***	0.34***	0.23*	−0.23*	−0.32***	−0.20*	0.30**	—					
12. Test anxiety	2.54	0.93	−0.12	0.33***	0.28**	**0.64***	0.45***	0.34***	−0.24*	−0.38***	−0.07	0.54***	0.40***	—				
13. Procrastination	2.75	1.05	−0.21*	0.28**	0.39***	0.43***	**0.76***	0.37***	−0.27**	−0.46***	−0.07	0.42***	0.43***	0.52***	—			
14. Poor sleep quality	0.35	0.72	−0.06	0.22*	0.16	0.44***	0.11	**0.60***	−0.26*	−0.31**	−0.15	0.27**	0.17	0.49***	0.27**	—		
15. Sleep duration and efficiency	3.51	0.64	0.10	0.01	0.10	−0.18	−0.05	−0.27**	**0.44***	0.20	0.11	−0.00	0.07	−0.27**	−0.06	−0.43***	—	
16. Sleep hygiene	47.73	5.93	0.08	−0.13	−0.35***	−0.39***	−0.36***	−0.42***	0.25*	**0.73***	0.08	−0.36***	−0.40***	−0.47***	−0.50***	−0.48***	0.30**	—

Note: Autocorrelations are presented in bold.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.
Abbreviations: M = mean, SD = standard deviation.

associations were modelled in the right-hand part of the figure, the parameters are nearly identical. As shown in the righthand part of Figure 2, controlled motivation was found to be most robustly related to both test anxiety and academic procrastination, as all associations were positive and significant paths (i.e., from the level-to-level, change-to-change, and level-to-change). Specifically, baseline levels of controlled motivation related to more test anxiety and procrastination, and both baseline levels as well as increases in controlled motivation to study were associated with increased test anxiety and procrastination from T1 to T2. For amotivation, a

TABLE 2 | Parameter estimates and fit indices of the univariate latent change model.

	Parameter estimates						
	Level		**Change**		**Fit indices**		
Variable	***Mean level***	**Variance (s^2)**	***Mean level change***	**Variance (s^2)**	**RMSEA**	**CFI**	**SRMR**
Autonomous motivation	3.52***	0.48***	0.00	0.21***	0.00	1	0.00
Controlled motivation	2.44***	0.26***	0.16**	0.16**	0.04	1	0.04
Amotivation	1.27***	0.27***	0.04	0.12**	0.00	1	0.03
Test anxiety	1.88***	0.44***	0.22**	0.41***	0.00	1	0.03
Procrastination	3.05***	0.85***	−0.32***	0.41***	0.00	1	0.01
Sleep quality	0.00	0.38***	0.38**	0.30**	0.00	1.00	0.015
Sleep duration and efficiency	3.49***	0.22***	−0.08	0.12	0.04	0.99	0.14
Sleep hygiene	3.99***	0.12***	0.01	0.04**	0.00	1	0.04

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

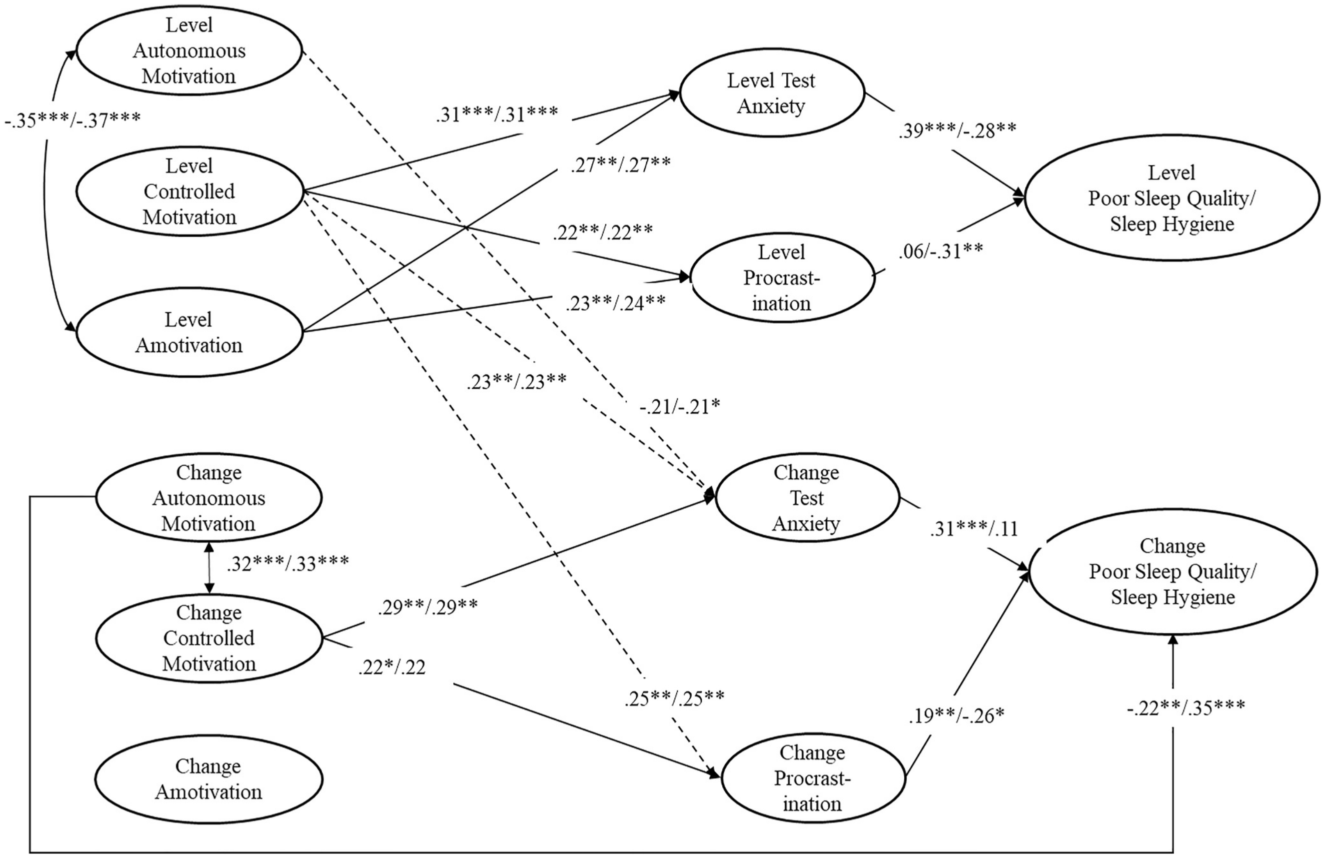

FIGURE 2 | Structural LCM for poor sleep quality (before slash) and sleep hygiene (after slash). *$p < 0.025$, **$p < 0.01$, ***$p < 0.001$. A separate model was tested for sleep quality (CFI = 0.912, RMSEA = 0.071, SRMR = 0.059) and sleep hygiene (CFI = 0.902, RMSEA = 0.070, SRMR = 0.068). Although no specific paths were hypothesised from study motivation to sleep directly, the fit for both models (sleep quality: CFI = 0.999, RMSEA = 0.029, SRMR = 0.039; sleep hygiene: CFI = 0.964, RMSEA = 0.053, SRMR = 0.050) improved notably when adding direct paths, suggesting that not all variance could be explained by the two intervening processes included. Therefore, structural models discussed below include direct paths. Paths from level to change within the same variable are not presented.

significant relationship was found with both test anxiety and procrastination in terms of the between person (i.e., level-to-level) associations. No change-to-change or level-to-change associations were significant for amotivation. Autonomous motivation was associated the least with both intervening processes, as only one level-to-change association was found between the baseline level of autonomous motivation with lower increases in test anxiety. This association was, however, only found in the sleep hygiene model, and not in the sleep quality model.

Hypothesis 3. *Associations between test anxiety, procrastination, and sleep. Test anxiety was related primarily to poor sleep quality, with the associations being significant at the three levels of analysis. This finding indicates that higher initial levels of test anxiety were related to poorer sleep quality, and that both higher baseline levels of test anxiety and increases in test anxiety were associated with a decline in sleep quality from pre-exams to exam period. As for the relation between procrastination and poor sleep quality, only the change-to-change association was significant, with an increase in procrastination being accompanied by a decrease in sleep quality.*

Regarding sleep hygiene, procrastination was more consistently associated with sleep hygiene (two out of three paths were significant) than test anxiety (one out of three paths was significant). Both baseline levels of test anxiety and procrastination are associated negatively with baseline level of sleep hygiene. In addition, there was a change-to-change association between procrastination and sleep hygiene, suggesting that an increase in procrastination went hand-in-hand with a decrease in sleep hygiene. No significant level-to-change associations were found between sleep hygiene and either procrastination or test anxiety.

3.3.2 | Objective 2: Testing an Integrated Model

Hypothesis 4. *the indirect role of test anxiety and procrastination. Some evidence was found for indirect effects (i.e., Hypothesis 4). In the sleep quality model, the indirect sequence from controlled motivation to poor sleep quality via test anxiety was robust, as this path was found to be significant at all levels of analysis (level-to-level: $\beta = 0.13$, SE = 0.05, $p = 0.002$; change-to-change: $\beta = 0.09$, SE = 0.04, $p = 0.010$; level-to-change: $\beta = 0.07$, SE = 0.03, $p = 0.030$). The indirect effect from baseline levels of controlled motivation to changes in poor sleep quality via changes in procrastination was also significant (level-to-change: $\beta = 0.05$, SE = 0.03, $p = 0.048$). One indirect effect was found for amotivation in terms of level-to-level association. The baseline level of amotivation predicted baseline levels of poor sleep quality through test anxiety (level-to-level: $\beta = 0.11$, SE = 0.04, $p = 0.010$). No indirect paths were observed for autonomous motivation. Autonomous motivation did display direct paths to poor sleep quality in terms of change-to-change associations ($\beta = -0.21$, SE = 0.08, $p = 0.008$).*

In the model for sleep hygiene, indirect effects were only significant in terms of level-to-level associations. There were indirect paths from initial levels of controlled motivation (level-to-level: $\beta = -0.07$, SE = 0.03, $p = 0.044$) and initial levels of amotivation (level-to-level: $\beta = -0.07$, SE = 0.03, $p = 0.025$) to lower initial levels of sleep hygiene through higher initial levels of procrastination. In addition, there was an indirect effect from initial levels of amotivation to lower initial levels of sleep hygiene via higher initial levels of test anxiety (level-to-level: $\beta = -0.07$, SE = 0.03, $p = 0.025$). Again, no indirect paths were observed for autonomous motivation. Yet, autonomous motivation displayed direct positive paths to sleep hygiene in terms of change-to-change ($\beta = 0.35$, SE = 0.10, $p = 0.001$) associations.

4 | Discussion

Although university students are prone to sleep problems during exams, few studies examined psychological contributors (Campbell et al. 2018). Test anxiety and academic procrastination are areas of concern, as they escalate during exams and are associated with sleep disruptions (Hamilton et al. 2021). Following SDT (Ryan and Deci 2017), these areas of concern may stem from poor-quality motivation. Whereas previous studies indicate that controlled motivation increases, and autonomous motivation decreases during exams (Cohen et al. 2022), no research has yet explored how motivational shifts are linked with students' sleep through test anxiety and procrastination. Investigating these shifts is essential, as findings may inform early intervention strategies to prevent a negative cycle of dysfunctional study attitudes and sleep problems during exams.

4.1 | Exams Increase Vulnerability to Poor Sleep, Test Anxiety and Controlled Motivation

Consistent with previous research (Gardani et al. 2022) and as previously reported in Campbell et al. (2018), students reported decreases in sleep quality during exams. No mean-level changes in the sleep duration and efficiency factor, nor in sleep hygiene were found, which is surprizing as poor sleep hygiene behaviours, such as late-night studying (Hartwig and Dunlosky, 2012) and increased caffeine and drug intake (Zunhammer et al. 2014) typically intensify during exams. One plausible explanation is that during exams, some aspects of sleep hygiene worsen while others improve. Additional repeated measures analyses on our sleep hygiene items showed that students engaged in more important work and ruminated more before bedtime during exams, but their sleep and wake times were less variable compared to an exam preparation phase. Students experienced heightened test anxiety during exam periods, which aligns with previous research where test anxiety fluctuated throughout the semester, peaking just before final exams (Lotz and Sparfeldt 2017). In contrast, academic procrastination decreased on average as students approached exams, suggesting exams may function as a catalyst to take action. This finding supports the discounting principle, according to which procrastinators find tasks less appealing when deadlines are distant but become more inclined to start and complete them as deadlines approach (Dewitte and Schouwenburg 2002).

Results only partly confirmed a decline in study motivation quality. On average, students' motivation became more controlled as exams approached. This finding indicates that motivation quality cannot only deteriorate over the school year (e.g., Cohen et al. 2022) but can also decrease during shorter periods of heightened pressure and evaluation. Although no mean-level changes were found for amotivation and autonomous motivation, there was substantial variance in students' changes. For example, 53.8% declined in autonomous motivation, yet 46.2% maintained or increased (Supporting Information S1 Figure S1). This variation suggests that unlike in secondary education (Cohen et al. 2022), higher education students may have more input in their learning environment or are better in motivating themselves. Amotivation remained relatively stable, with most students showing little change and only a few exhibiting sharp increases or decreases (Supporting Information S1 Figure S2).

4.2 | Controlled Motivation and Amotivation

Further, we aimed to examine whether study motivation would affect sleep through test anxiety and procrastination. Extending cross-sectional findings (Vansteenkiste et al. 2005; Vansteenkiste et al. 2009), significant associations between controlled motivation and both anxiety and procrastination were found concurrently (level-to-level associations) and longitudinally (change-to-change and level-to-change associations). Higher initial levels of controlled motivation related to higher initial levels of test anxiety and procrastination and were, at the same time, predictive of changes in these variables from 1 month before exams to the exam period. Increases in controlled motivation also went hand-in-hand with increases in test anxiety and procrastination. The finding that controlled motivation was associated robustly with both test anxiety and procrastination deviates slightly from our hypotheses as controlled motivation was expected to relate primarily to test anxiety. Apparently, controlled motivation can contribute simultaneously to strong concerns about exams and a tendency to postpone study efforts. The latter could reflect a self-handicapping strategy, where students procrastinate to create an excuse for failure and to preserve their self-worth (Schwinger et al. 2014).

Amotivation was expected to be related primarily to procrastination, a prediction confirmed in terms of level-to-level associations but not for longitudinal associations. The operationalisation of amotivation and procrastination may help to explain this. While amotivation can stem either from a lack of interest and value or from perceived inability to complete tasks (Legault et al. 2006), this distinction is not reflected clearly in the items used (e.g., 'I'm not sure why I am studying'). Similarly, while academic procrastination is often linked to self-regulation (Zhang et al. 2018), it can also stem from feelings of incompetence or anxiety (Grunschel et al. 2012). Moreover, whereas amotivation is typically linked with a complete disengagement from studying, the items for procrastination in this study focused more on delaying or deviating from planned study activities (e.g., 'I tend to start studying later than I originally planned'). Future research should use more refined measures to better capture the complex relationship between amotivation and procrastination. Another somewhat unexpected finding was that amotivation related to test anxiety, with this association occurring in terms of the level-to-level. Again, the distinction between value-based amotivation and competence-based amotivation may provide an explanation. Whereas students who do not see the value of studying may no longer care about exams (thus not experiencing elevate test anxiety), students who are demotivated because of concerns about incompetence may still see the importance of exams and experience a strong sense of anxiety because they anticipate further failure.

In line with Hypothesis 3, students higher in test anxiety were more likely to experience poorer levels and reductions in sleep quality, whereas procrastinators were more likely to face problems with sleep hygiene. The present study adds to the literature (Hamilton et al. 2021) by showing that test anxiety and procrastination are linked with sleep somewhat differently, indicating that distinct approaches may be needed to target each type of sleeping problem.

Indirect pathway analyses addressing Hypothesis 4 confirmed a negative sequence linking controlled motivation to poor sleep quality through increased test anxiety at all three levels of analysis. The second hypothesised sequence, from amotivation to sleep hygiene via academic procrastination, was confirmed only at the between-person level. This may be due to the differences in the degree of heterogeneity observed at the level of within-person change in the sleep outcomes—55% for sleep quality versus 4% for sleep hygiene. While the variance was significant in both cases, the variance in sleep hygiene may not be substantial enough to reveal meaningful relationships at the level of longitudinal changes. Overall, the results consistently underscore the harmful role of controlled motivation during exam (preparation) periods, adding to evidence that it negatively affects academic achievement and adaptation in higher education (Holding et al. 2021).

4.3 | Autonomous Motivation

Aligned with research on the benefits of autonomous motivation for performance and well-being (Howard et al. 2021), results show that autonomously motivated students were better protected against sleep problems during exams. Specifically, increases in autonomous motivation during exams relate to a smaller decrease in both sleep quality and hygiene during exams.

Contrary to our hypotheses, results revealed only direct effects for autonomous motivation instead of indirect effects via test anxiety and procrastination. This might be explained by the intervening variables reflecting maladaptive factors. In line with the finding that motivational factors involved in the dark side of students' functioning are distinct from factors involved in the bright side of their functioning (Howard et al. 2021), more adaptive factors may account for the relationship between changes in autonomous motivation and sleep. One candidate is subjective vitality or one's state of energy and enthusiasm.

Autonomous motivation is known to energise and promote vitality among university students (Nix et al. 1999). If students are more autonomously motivated to study, they likely feel that their time is well-spent and meaningful, reducing evening compensation thus improving sleep hygiene. Additionally, vitality is associated with better self-control (Muraven et al. 2008), which is crucial for maintaining healthy sleep routines.

Another candidate is students' physiological response to threats and stressful events. Steel et al. (2020) found that high-quality motivation was linked to lower cortisol responses, while low-quality motivation was associated with higher cortisol levels (Reeve and Tseng 2011). They suggested that high-quality motivation might lead to perceiving stressful situations as less threatening, thus reducing cortisol and other physiological responses (Steel et al., 2020–2021). Autonomously motivated students likely view exams as learning opportunities rather than threats, with these benign appraisals reducing poor sleep quality.

4.4 | Limitations

The current study has some limitations that could be addressed in future research. Certain characteristics of our sample may limit the generalisability of the findings to other student populations. First of all, all analyses were performed on a relatively small sample of 121 students, which may impact the robustness and generalisability of our findings. The limited sample size reduces the statistical power of the study, making it more difficult to detect subtle effects or variations that might emerge in larger, more diverse groups. Additionally, given that the sample consisted of only Belgian students and 78.5% were female, our sample does not fully capture the diversity of the student population, which could lead to bias in the results or limit the extent to which the conclusions can be applied to broader or different student populations.

The study does not allow for causal conclusions, and the link between test anxiety and sleep might be bi-directional. While testing for bi-directionality would be highly valuable, it fell outside the scope of the present study. Additionally, the limited sample size and the use of only two measurement occasions constrained our ability to examine these associations effectively. Future research should employ more intensive longitudinal designs, such as daily diary studies, which allow for testing bi-directionality using approaches like cross-lagged panel models.

Additionally, certain variables that could influence the results were not assessed in the present study. For example, bachelor and Master students were not distinguished and we were unable to account for differences in universities or academic majors (e.g., art, science) because both were not surveyed. Typically, the Master years allow for more personal choice in curriculum, which could impact the relative autonomy of study motivation. Different academic disciplines often entail varying curricular demands and stressors, which could affect levels of test anxiety and related constructs. Also, the current study was also unable to account for perceived performance during previous exams, nor did we include any measure for specific characteristics of exams, such as whether the exams were online or in person. Because the second measurement period coincided with a week when students had the most exams, their feelings of competence and self-efficacy—based on how well they performed on prior exams—could have influenced their study motivation and test anxiety. These additional variables warrant further exploration in future work.

Because all measures were self-reported, shared method variance may have inflated some of the observed associations. Future research could rely on actigraphy (i.e., sleep watches), allowing for more reliable measures of sleep duration and sleep interruptions. Additionally, given that self-reports of test anxiety primarily focus on cognitive rather than physiological aspects of test anxiety Liebert and Morris 1967), future work could include more objective indicators of test anxiety such as heart rate variability.

4.5 | Practical Implications

Previous studies suggest that managing test anxiety and procrastination during exams can be challenging (Grunschel and Schopenhauer 2015). Findings from the present study suggest that intervening early-on by focussing on study motivation is promising. Interventions aimed at improving study motivation can be applied at various levels. First, helping late adolescents make informed, autonomously motivated study choices (Vermote et al. 2023) could improve alignment of interests with their study programme, thereby fostering greater autonomous motivation throughout the semester and exams. Second, interventions could target the broader educational environment. Teachers' motivational styles significantly affect students' autonomous motivation (Aelterman et al. 2019). However, lecturers often unknowingly use fear-based approaches when conveying exams and study material information (Putwain and Remedios 2014). Observation tools might create (self-)awareness of (de)motivational messages and strategies (Kingma et al. 2024). Lecturers could also be encouraged to use autonomy-supportive strategies, such as providing meaningful rationales for learning (Vermote et al. 2020). The overall motivational climate within a school or university plays a pivotal role in the success of school-based interventions (van de Casteele et al. 2022). Third, university students can benefit from training or tools directly fostering proactive management and monitoring of their motivation. Agentic engagement involves students actively shaping their environment to support their needs and goals (Patall 2024), which can include giving input on course material, seeking feedback, and setting personalised study schedules. Fostering agentic engagement can enhance engagement and interest (Patall et al. 2022). Need crafting, where students proactively seek contexts and support that fulfil their psychological needs is a valuable route for interventions, as online interventions focussing on need crafting improve autonomy, competence and relatedness during stressful periods (van den Bogaard et al., 2024). Future interventions could inform students through psychoeducation and self-motivational strategies about ways to enhance their own motivation quality.

5 | Conclusions

This two-wave longitudinal study found that from pre-exams to exams, on average, university students' poor sleep quality, test anxiety, and controlled motivation increased, while academic procrastination declined. Structural LCM analyses revealed a consistent and strong relationship between controlled motivation and both test anxiety and procrastination. In turn, test anxiety was found to be linked primarily to poor sleep quality and procrastination to be linked primarily to low sleep hygiene. Tests of indirect effects mainly highlighted a negative sequence where controlled motivation led to poorer sleep quality through increased test anxiety, a sequence observed across all levels of analysis. By contrast, autonomous motivation played a more direct and protective role, as higher levels and increases in autonomous motivation were associated with less deterioration in sleep quality and sleep hygiene during exams.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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