Title: The mediating role of mood in the relationship between perseverative cognition, sleep and subjective health complaints in music students.

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The mediating role of mood in the relationship between perseverative cognition, sleep and subjective health complaints in music students

Abstract

Objective: Subjective health complaints (SHC) are frequent in musicians. These complaints may be particularly distressing in this population because they are performance-relevant. This paper aims at testing a model positing that (a) perseverative cognition (PC) predicts sleep duration/quality, (b) sleep duration/quality predicts SHC and (c) mood is a mediator of these associations.

Design: Participants were 72 music students (mean age (SD): 22.7 (3.0) years), and the assessment period consisted of seven consecutive days, with a solo performance on the fifth day.

Main Outcome Measures: Self-reported total sleep time (TST) and sleep quality were assessed 30 minutes after wake-up, and objective TST/sleep quality were assessed with an actigraphy watch. PC and mood were measured five times a day. Daily SHC were assessed at 9 p.m.

Results: PC did not significantly predict sleep duration/quality. Self-reported and objective TST and sleep quality were all significantly associated with SHC. Mood played a mediating role in each of these relationships with the exception of objective sleep quality.

Conclusion: The tested model on the association between PC, sleep and SHC and the mediating role of mood received partial support, highlighting the importance of sleep and mood in the emergence of SHC among university music students.

Keywords: mood, perseverative cognition, subjective health complaints, sleep duration, sleep quality, music students

Introduction

Research indicates that subjective health complaints (SHC, Eriksen & Ihlebaek, 2002) are frequent in musicians, particularly musculoskeletal pain (Fishbein, Middlestadt, Ottati, Straus, & Ellis, 1988; Kimiväki & Jokinen, 1994): Lower back, neck and shoulder are the most commonly mentioned sites for musculoskeletal SHC. Also eye strain and stage fright are frequently reported. In a study by Halleland, Harris, Sørnes, Murison and Ursin (2009), 96.9% and 81.3% of the members of an orchestra indicated SHC (including musculoskeletal complaints, pseudoneurological complaints, gastrointestinal complaints, allergies, and cold) during the past 30 days. Although this finding is comparable with normative data (Halleland et al., 2009), these symptoms might be particularly distressing for musicians because of their performance-relevant character. With respect to musculoskeletal problems, Paarup, Baelum, Holm, Manniche and Wedderkopp (2011) reported higher prevalence among musicians than in the general population. SHC are common reasons for sick leave and seeking medical consultation (Picavet & Schouten, 2003) and are thus responsible for considerable healthcare costs and loss of productivity (Eriksen & Ihlebaek, 2002). In musicians, SHC can have career-threatening consequences (Kenny, 2011). It is thus important to understand better the mechanisms underlying the emergence of SHC in musicians. In the present paper, we aimed at investigating the possible role of sleep, perseverative cognition (PC) and mood in the development of SHC.

Various studies have shown that sleep deprivation or sleep disturbances were predictive of increased subjective health complaints (SHC) such as headache, sore throat, anxiety or depression (Kahn-Greene, Killgore, Kamimori, Balkin, & Killgore, 2007; Paiva, Gaspar, & Matos, 2015; Tkachenko et al., 2014). In professional musicians, 13-24% are affected by sleep disturbances (Raeburn, Hipple, Delaney, & Chesky, 2003; Fishbein et al., 1988; Brodsky, 1995).

In a recent study, Vaag, Saksvik-Lehouillier, Bjorngaard and Bjerkeset (2015) reported higher prevalence of insomnia symptoms in Norwegian musicians compared to the general workforce mainly due to differences with respect to the restorative potential of sleep and satisfaction with sleep.

Sleep is one of the most important recovery processes, in particular during a period including a stressful event (Campbell, 1992; Zijlstra & Sonnentag, 2006). Recovery has been defined by Demerouti, Bakker, Geurts and Taris (2009, p. 90) as the "process that repairs the negative strain effects" and helps the organism to activate the resources (energetic and emotional) to avoid fatigue and negative consequences for health. Recovery implies the return to baseline levels of the different systems to "recharge the batteries" on the physiological level and feeling ready again for upcoming solicitations on the psychological level (Zijlstra & Sonnentag, 2006). In an acute stress response, the normal bodily reaction is an instantaneously increased psychophysiological activation followed by a rapid return to baseline levels (McEwen & Seeman, 2003). Continuous worrying and ruminating about stressful past or (potential) future events, often subsumed under the umbrella term 'perseverative cognition' (PC), keeps the organism in a state of physiological arousal and can, thereby, lead to a prolonged stress situation. This may impair the recovery process and lead to somatic diseases (Brosschot, Gerin, & Thayer, 2006, Ottaviani et al., 2016; Verkuil, Brosschot, Gebhardt, & Thayer, 2010).

PC has been shown to influence sleep parameters. Zoccola, Dickerson and Lam (2009) found that PC increased subjective sleep onset latency but was not linked to total sleep duration. In their longitudinal study analyzing the links between work-related stress, subjective sleep quality and PC, Van Laethem et al. (2015) found that less PC resulted in better subjective sleep quality.

PC, sleep parameters and SHC have all been associated with mood. Moods can be defined as "rather diffuse affective states that subtly affect our experience, cognitions, and behavior" (Wilhelm & Schoebi, 2007, p. 258). In a systematic review and meta-analysis, Ottaviani et al. (2016) reported an association between rumination and worry on the one hand and the worsening of mood on the other. With respect to sleep, Meney, Waterhouse, Atkinson, Reilly and Davenne (1998) found that self-reported tension, depression and fatigue were higher the day after a sleep deprivation night than after a normal night in healthy men. Lastella, Lovell and Sargent (2014) observed that longer self-reported sleep duration and better subjective sleep quality were associated with lower tension and fatigue in athletes the night preceding a competition. In an ambulatory assessment study including depressed and control participants, Bouwmans, Bos, Hoenders, Oldehinkel and de Jonge (2017) found that good subjective sleep quality predicted better affect during the following day. Finally, mood has been associated with SHC. Verkuil, Brosschot, Meerman and Thayer (2012) found that during a six-day period, higher levels of negative affect during the day significantly predicted more SHC in the evening among teachers. Furthermore, in a correlational study, Villanueva, Górriz, Prado-Gascó and González (2015) found that higher negative mood was associated with more SHC.

Applying a common sense psychological arguing, we suggest the following pathway to integrate the above mentioned pieces of scientific evidence with respect to the associations between PC, sleep, SHC and mood: More PC would negatively affect sleep duration and quality, which, in turn would increase SHC. Mood would be a significant mediator of these relationships (see Figure 1).

[Insert Figure 1]

The goal of the present paper was to test this theoretical framework. It was tested in a population of university music students during a 7-day period that included a solo performance on the fifth day. First, we hypothesized that PC duration is predictive of shorter sleep duration and worse sleep quality of the following night (as proxy for recovery) and that mood mediates a significant proportion of these relationships. Second, we hypothesized that shorter sleep duration and worse sleep quality are predictive of more SHC on the following day and that mood mediates a significant proportion of these relationships. Agreement between subjective and objective sleep parameters can vary considerably (Lockley, Skene, & Arendt, 1999). Therefore, to give a more complete picture of sleep, we assessed both subjective and objective measures of sleep.

The variables of main interest were previously shown to be potentially affected by the consumption of caffeinated beverages, alcoholic beverages and tobacco (e.g., Loke, 1988; Verkuil et al., 2012), as well as by depressive symptoms (e.g., Nolen-Hoeksema, 2000; Tsuno, Besset, & Ritchie, 2005). Therefore, we assessed these variables and included them in the analyses testing our hypotheses.

Methods

Participants

Seventy-two music students from five XXXX Music Universities participated in the study. Participants' age ranged from 18 to 30 years, with a mean of 22.7 years (*SD* = 3.0), and 67 % were women. Furthermore, 31.9 % of the music students were studying in the first academic year, 20.8 % in the second, 16.7 % in the third, 12.5 % in the fourth, 4.2 % in the fifth and 13.9 % in the sixth or seventh year. The instrument types were strings (31.9 %), woodwind (27.8 %), voice (16.7 %), piano (11.1 %), brass (9.7 %) and other (2.8 %). They practiced their main instrument an average of 4.9 hours per day (*SD* = 1.6). Sixty-two participants spoke French and 10 spoke German.

Music students suffering from endocrinological and cardiovascular disorders were excluded. Major depression syndrome, bulimia, binge eating disorder and alcohol abuse as assessed using the Patient Health Questionnaire (Spitzer, Williams, Kroenke, Hornyak, & McMurray, 2000) and wearing a pacemaker, working night shift, being pregnant or lactating were additional exclusionary criteria. Also using psychoactive drugs or other medication with effects on the central and autonomic nervous systems, the cardiovascular system or the endocrine system were considered as exclusionary criteria.

The study was approved by the local ethics committee of XXX, and all music students gave their informed consent to participate. The music students were remunerated 500 XXXX for their participation.

Procedure

Data presented in this paper were collected as part of a larger field study on music performance anxiety (MPA) investigating psychological and physiological variables (e.g. cortisol and alpha-amylase levels during the day, ECG during the night) over seven days.

Recruitment. Music students were recruited through flyers and word of mouth. Prospective volunteers were sent an electronic link containing recruitment questionnaires assessing demographic, academic and health-related data.

Experimental phase. Participants were assessed during seven days, with a study concert organized on the 5th day between 3 p.m. and 7 p.m. The participants had no other solo performances during this 7-day period. They were asked to fill in several questionnaires up to five times per day (see below).

Measures

The recruitment questionnaire was administered via an online questionnaire using the software EFS Survey (©UNIPARK & QuestBack, Germany). During the experimental phase, the music students filled in questionnaires with an iPod touch 5 (© Apple) using iDialogPad developed by Gerhard Mutz at the University of Cologne, Germany.

~~*Sleep.* Although subjective and objective sleep parameters are often correlated, agreement between the two can vary considerably (Lockley, Skene, & Arendt, 1999). Thus, in order to give a more complete picture of sleep, we assessed both self-reported and objective sleep parameters.~~

Self-reported sleep duration and quality. Once a day, 30 minutes after awakening, we assessed self-reported total sleep time (TST, in hours) and sleep quality of the preceding night with the Saint Mary's Hospital Sleep Questionnaire (SMH; Ellis et al., 1981). TST was determined with the item "How much sleep did you have last night?" The participants also reported the time of falling asleep and the time of wake-up. We compared the self-reported TST and the sleep duration calculated by the difference of times between falling asleep and wake-up and excluded the data if the two scores differed from each other by more than one hour. Additionally, data were excluded if the difference between the self-reported and objective TST were larger than 2 hours. We excluded 23% of the TST data from the analyses. Sleep quality was assessed with the item "How well did you sleep last night?" with response modalities ranging from 1 "very badly" to 6 "very well". The French version of the SMH was taken from Billiard

(1994), and the German items were translated from the French version and back translated to French by the authors.

Objective sleep duration and quality. The objective sleep duration and quality were measured during the seven measurement nights by means of an actigraphy watch (MotionWatch8, ©CamNtech, Papworth Everard, United Kingdom). Programming and analyses were done using the MotionWare software. This software calculates the actual sleep duration, by excluding the awakening periods during the night. The fragmentation index represents the fragmentation degree of the sleep period and was used to represent lack of sleep quality (Naeck et al., 2009; Landry, Best, & Liu-Ambrose, 2015). The fragmentation index can vary from 0 to 100, with lower scores indicating better sleep quality.

Subjective Health Complaints (SHC). Once a day, at 9 p.m., we assessed the SHC experienced during the past 24 hours with the Subjective Health Complaints Inventory (Eriksen, Ihlebaek, & Ursin, 1999). It contains 29 single items (e.g., headache) that are evaluated on a 4-point scale with 0 = not at all, 1 = a little, 2 = some and 3 = serious. The summed score, varying from 0 to 87, was used in the analyses. The French and the German version of the questionnaire were translated from the English version and back translated to English by the authors. Previous work has reported Cronbach's alphas between 0.75 and 0.82 for the total score of all items (Eriksen et al., 1999; Verkuil et al., 2012). In the present study, Cronbach's alphas for each measurement day ranged between 0.73 and 0.86 ($M = 0.81$).

Mood. Five times a day (30 minutes after wake up, at 11 a.m., 2 p.m., 6 p.m. and 9 p.m.), participants were asked to answer the multidimensional Mood State Questionnaire Short-scale (German and French versions by Wilhelm & Schoebi, 2007, based on the Multidimensionaler Befindlichkeitsfragebogen by Steyer, Schwenkmezger, Notz, & Eid, 1997~~; see same references~~

~~for psychometric properties of the instruments~~). This questionnaire assesses three dimensions of mood (following the conceptualization of Matthews, Jones, & Chamberlain, 1990 and Schimmack & Grob, 2000): valence (bad/good), calmness (tense/calm) and energetic arousal (tired/awake). Each dimension is composed by two bipolar scales ranging from 1 to 8 and with two adjectives as anchors (e.g. "Right now I feel tired/awake"). Scores for the three dimensions are the average of the two scales for each dimension, with higher scores corresponding to better mood. Wilhelm and Schoebi (2007) reported Cronbach's alphas for their 2-item subscales between 0.70 and 0.77. In the present study, the mean Cronbach's alphas for valence, calmness, and energetic arousal across all assessments were 0.77, 0.82, and 0.83. We performed a factor analysis with the six mood scales to determine whether the number of facets of mood could be reduced. Only one factor with eigenvalue > 1 (2.81) emerged, and all six mood scales had their highest loading on this factor with values between 0.60 and 0.76. In accordance with these results, the mean Cronbach's alpha for the total score of the mood scales across all assessments was 0.82. Thus, for the sake of parsimony, we collapsed the three scores into one. We created a daily mean of the six mood scales for each participant and used this score for the mediation analyses. We will refer to this score as "mood" in the analyses.

Perseverative cognition (PC). We created a questionnaire to assess the daily perseverative cognition, inspired by Verkuil et al. (2012) and Pieper, Brosschot, van der Leeden and Thayer (2010). Five times a day, together with the assessment of mood, participants answered the following question: "Since the last assessment time, have you had any thoughts or images related to negative problems, preoccupations, events, experiences or situations from the past, the present or the future?" If they answered affirmatively, they were asked to indicate the duration of these thoughts/images in minutes since the last prompt. For each day, we computed the total duration of PC in minutes. The absence of PC was coded as 0 minutes.

Stressful events. We assessed stressful events at the same times as mood and PC. Participants were asked if they had experienced any stressful event since the last assessment time. We provided the following definition of a stressful event based on Verkuil et al. (2012): "Stressful events are minor and major events that have made you feel tense, irritated, angry, sad, disappointed or negative in any other way". The answers were coded 0 (no) or 1 (yes), and a daily mean was calculated.

Biobehavioral variables. Because of their potential influence on the variables of main interest (e.g., Loke, 1988; Verkuil et al., 2012), we assessed the daily consumption of caffeinated beverages, alcoholic beverages and tobacco. Together with the number of stressful events, the participants reported whether they had consumed caffeine, alcohol or tobacco since the last assessment time. Answers were coded as 0 (no) or 1 (yes), and a daily mean for each variable was computed.

Depressive symptoms. Before the start of the 7-day assessment period, we also assessed depressive symptoms with the Beck Depression Inventory (BDI; Beck, Steer, Ball, & Ranieri, 1996). This variable was included in the analyses to control for the possible effects of depressive symptomatology on the variables of main interest (e.g., Nolen-Hoeksema, 2000; Tsuno, Besset, & Ritchie, 2005). The internal consistency for the BDI in our sample was satisfactory (Cronbach's $\alpha = .78$). Beck et al. (1996) reported a Cronbach's alpha of .91.

Statistical analyses

All statistical analyses were performed with STATA 14 (Stata Statistical Software; StataCorp LP, College Station, TX). We set the significance level at .05 for all statistical tests.

~~A factor analysis with the six mood scales yielded one main factor. Thus, we created a daily mean of the six mood scales for each participant and used this score for the mediation analyses. We will refer to this score as "mood" in the analyses.~~

For the statistical analyses, we followed the model suggested by Baron and Kenny (1986). This model posits four preconditions for mediation: First, the overall link between the predictor and the outcome is significant. Second, the link between the predictor and the mediator (i.e. mood) is significant. Third, the strength of the link between predictor and outcome variable decreases when controlling for the mediator. Fourth, the link between mediator and outcome is significant. All the mediation analyses were tested with linear mixed models fitted using restricted maximum-likelihood acknowledging between-day heteroskedasticity. This statistical approach is necessary because of the multilevel structure of the data set (West, Welch, & Galecki, 2015). We tested the models with a random intercept for each participant and fixed effects for the factors of main interest. For the first mediation analyses concerning the relationships between PC and sleep, the factor of main interest was PC duration with the sleep parameters as outcome measures and mood as mediator. For the second mediation analyses concerning the relationships between sleep and SHC, the factors of main interest were the sleep parameters with SHC as outcome measure and mood as mediator. We also controlled for stressful events, PC duration on the current day (for the second mediation analyses only), age, gender, caffeine consumption, alcohol consumption, tobacco consumption and depressive symptoms. From these analyses, we obtained the estimated mediated proportion of mood for the link between the predictor and the outcome variable. In order to obtain the confidence intervals of these mediated proportions, we performed bootstrap sampling with 1000 replications (Preacher & Hayes, 2004). According to this method, if the zero does not fall in the confidence interval, the mediation is significant at $p < .05$ (Preacher & Hayes, 2004). The confidence intervals given are the bias-corrected intervals. According to Carpenter and Bithell (2000), this is the most accurate method for confidence intervals when using the software STATA. Because SHC was not normally distributed, we log-transformed this variable.

Results

Table 1 shows means, standard deviations and min/max values of all variables.

[Insert Table 1]

Mediation of the relationship between PC and sleep parameters by mood

PC duration had no significant effect on any of the subjective and objective sleep parameters of the following night (*p*s > .09). This being, the criteria were not met to carry out mediation analyses.

Mediation of the relationship between self-reported TST and SHC by mood

The estimated models and the estimated mediated part are given in Table 2. First, self-reported TST was negatively and significantly associated with SHC. Second, self-reported TST and mood were positively and significantly associated. Third, the relationship between mood and SHC was negative and significant when controlling for self-reported TST. Thus, all prerequisites for the mediation analysis were met. Finally, when controlling for the mediator variable, i.e. mood, the relationship between self-reported TST and SHC became smaller and less significant, showing that mood served as mediator between self-reported TST and SHC. On average, mood mediated

25% of the relationship between self-reported TST and SHC. Sleeping one additional hour was associated with a 9.1%[1] decrease in SHC. When including mood as mediator, the SHC decrease with one additional hour of sleep was 7.5%.

[Insert Table 2]

Mediation of the relationship between objective TST and SHC by mood

The estimated models and estimated mediated part are given in Table 3. As with self-reported TST, all the criteria were met to assert that mood mediated the relationship between objective TST and SHC. On average, mood mediated 22% of the relationship between objective TST and SHC. Sleeping one additional hour as determined by the actigraphy watch led to an 11.1% decrease in SHC. When including mood as a mediator, the SHC decrease with one additional hour of sleep was 9.6%.

[Insert Table 3]

Mediation of the relationship between self-reported sleep quality and SHC by mood

As shown in Table 4, all the criteria were met to assert that mood mediated the relationship between self-reported sleep quality and SHC. On average, mood mediated 30% of the relationship between self-reported sleep quality and SHC. Judging one's own sleep quality more positively by one point reduced SHC by 7.6%. When including mood as a mediator, the SHC decrease with one additional point was 5.1%.

[Insert Table 4]

Mediation of the relationship between objective sleep quality and SHC by mood

The estimated models are given in Table 5. More sleep fragmentation (i.e., worse objective sleep quality) significantly predicted more SHC. More sleep fragmentation was not a significant predictor of mood (p = .50). Thus, the mediation criteria were not met for the objective sleep quality.

[Insert Table 5]

Discussion

The present paper aimed at testing a model integrating existing pieces of current scientific evidence on the association between PC, sleep parameters, SHC, and mood. The model posits that (a) PC predicts self-reported and objective sleep duration/quality, (b) sleep duration/quality predicts SHC and (c) mood is a mediator of these associations. The model was tested in university music students, a population known to report high levels of SHC, during a potentially stressful period including a solo performance.

Our analyses show partial support for the suggested model. Whereas the first part of the model (i.e., PC predicts sleep parameters) was not supported by our results, the hypotheses concerning the second part of the model (i.e., sleep parameters predict SHC) were confirmed: Self-reported and objective parameters of sleep duration and quality clearly predicted SHC on the following day. Furthermore, the mediator role of mood in these relationships was confirmed (with the exception of objective sleep quality).

Contrary to our results, Van Laethem and colleagues found a significant association between PC and objective sleep efficiency in PhD students (Van Laethem et al., 2016) and self-reported sleep quality, number of awakenings during the night and duration of wake after sleep onset in employees (Van Laethem et al., 2015). These conflicting findings might be due to methodological differences across the studies with respect to the chosen items for PC and sleep quality, the assessment time point, the study duration and the sample size. More precisely, whereas Van Laethem et al. (2015, 2016) asked their participants to rate their PC qualitatively (e.g., "I can easily detach myself from my work"; Van Laethem et al., 2015) or to give a yes/no answer ("Did you have perseverative cognition about (…)?"; Van Laethem et al., 2016), we asked for a quantitative estimate of PC duration. On average, our participants reported 25 minutes of PC per day. This is in the same range as reported by Brosschot and van der Doef (2006) and Verkuil et al. (2015) who found average PCs between 24 and 37 minutes per day in healthy individuals over 6- and 14-day periods, respectively. Furthermore, whereas we assessed general daytime PC as a state measure to predict sleep quality of the following night, van Laethem et al. (2015) assessed exclusively work-relevant PC as a trait measure to predict self-reported sleep quality over a 4-weeks period 13 months later in a sample of 877 employees. Contrary to the single-item used in our study, their measure of sleep quality included four dimensions: (i) difficulty initiating sleep, (ii) awakening during the night, (iii) difficulty maintaining sleep including waking up too early, and (iv) nonrestorative sleep. In the second study, Van Laethem et al. (2016) followed 44 PhD students over a two-months period and assessed them on 8 occasions: four weeks, one week, three days and one day before their doctoral thesis defense as well as one day, three days, one week and four weeks after their defense. PC concerning various life domains (thesis defense, work, job insecurity, sleep, family, etc.) was assessed retrospectivly on the morning referring to the state at bedtime of the preceding night and/or during that night. Also, the assessed period in our study might have been less stressful than the one in Van Laethem et al. (2016). Whereas the doctoral thesis defense is a unique event with no possibility for habituation effects, our participants might have been much more familiar with musical performance which is a recurrent situation for music students.

The hypothesis concerning the second part of the model, i.e., that shorter sleep duration and worse sleep quality lead to more SHC, was confirmed for all self-reported and objective sleep parameters. This clearly shows the importance of sleep on subjective well-being represented here by SHC giving further evidence to the restorative potential of sleep (Zijlstra & Sonnentag, 2006). Furthermore, mood mediated a significant proportion of the relationships between sleep parameters and SHC (with the exception of objective sleep quality, which was not associated with mood). This being, the magnitude of the relationships between self-reported and objective sleep duration and self-reported sleep quality on the one hand and SHC on the other hand was reduced when including mood as a mediator. These results show that mood plays an important role in the emergence of SHC. These findings are in line with previous studies (Verkuil et al., 2012, Villanueva et al., 2015) showing that less positive mood predicts higher SHC. Thus, self-reported and objective sleep duration and self-reported sleep quality can influence SHC either directly or indirectly via mood. Objective sleep quality as indexed by sleep fragmentation also negatively influenced SHC but not through effects on mood. One possible explanation for the discrepancy in the relationship between subjective and objective sleep quality and mood is that the measure of sleep fragmentation is more specific than the one of subjective sleep quality. The latter takes more aspects into account while the former one does not tell the whole story about a night's sleep and may, therefore, be less strongly related to mood. In future research, information about sleep fragmentation could be complemented by other objective measures of sleep quality such as deep-sleep portion of total sleep time in order to assess objective sleep quality more comprehensively. This approach may allow a stronger relationship between objective sleep quality and mood to be found. In conclusion, for improving the general health of music students, SHC could be reduced through interventions aiming at either increasing sleep duration, improving sleep quality and/or improving mood.

Limitations of the study

The present study has some limitations that offer possible avenues for future research. First, we measured SHC every evening at 9 p.m. and asked the participants to report SHC experienced during the preceding 24 hours. This being, some SHC might have happened before or during the preceding night. In a future study, it might be more adequate to consider daytime SHC of the current day only (i.e., since wake up). Second, PC was operationalized in terms of duration. Other aspects of PC might be important to consider in order to understand the potential effects of PC on sleep and health. Thus, a more detailed characterization of PC in terms of frequency and intensity (Verkuil et al., 2012) and repetitiveness, intrusiveness, difficulty with disengagement (Ehring, Zetsche, Weidacker, Wahl, Schonfeld, & Ehlers, 2011) may refine the picture. Third, the 7-day assessment period represents well a typical week in the music students' academic life. It would be important to test whether the same relationships observed in this study are replicated during different periods of the students' life (e.g., holidays, exam session). Fourth, mood was conceptualized in terms of valence, calmness and energetic arousal. There are other possible ways of defining and measuring mood (e.g., Profile of Mood States; McNair, Lorr, & Droppelman, 1971), and these could be considered in future investigations. Fifth, we used an actigraphy watch to assess objectively sleep duration and quality. The use of polysomnography, which is considered the gold standard in sleep research (Van de Water, Holmes, & Hurley, 2011), might be an important next step in investigating the relationships between PC, sleep, mood, and SHC. Finally, we focused on music students. The suggested theoretical framework should be applied to other populations before concluding on the generalizability of our results.

Conclusion

In conclusion, our suggested model received partial support. We could not show that PC duration significantly predicted sleep quality and quantity. Yet, our results confirm the importance of sleep and mood (as mediator) with respect to the experience of SHC in a population of music students during a demanding period including a musical performance. Mood was a significant mediator of the relationships between self-reported sleep duration, objective sleep duration, and self-reported sleep quality on the one hand and SHC on the other hand. Sleep and mood might thus represent two promising starting points for interventions facilitating the recovery process in music students and helping them decrease SHC.

Footnotes

[1] The regression analysis assumes a linear relation between TST in hours and the log-transformed SHC score: Log(score)= a - b x TST. Thus, the predicted log(score) decreases by b if the TST increases by 1 (hour), that is, the non- log transformed SHC score is multiplied by Exp(b). In other words, for one hour more sleep, the SHC score decreases by 100 x (Exp(b)-1).

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Table 1: means (standard deviations), minimum and maximum of each variable. As the baseline variables, the time-dependent variables represent the average by participant.

		M (SD)	Min	Max
Baseline variables	Academic year	2.83 (1.84)	1	7
	Female	67%	-	-
	Age (years)	22.70 (3.00)	18.00	30.00
	BDI (0 (no depression)-63)	6.19 (4.98)	0.00	21.00
Time-dependent variables	SHC (0 (no SHC)-87)	7.46 (5.71)	0.00	27.00
	Self-reported TST (hours)	7.31 (0.62)	5.34	8.73
	Objective TST (hours)	6.47 (0.53)	5.32	7.69
	Self-reported sleep quality (1 (very bad)-6 (very good))	4.38 (0.64)	2.80	5.50
	Objective sleep quality (0 (good)-100 (bad))	27.75 (9.03)	13.55	65.29
	Mood (1 (bad)- 8 (good))	5.91 (0.70)	4.33	7.42
	Stressful event (0-1)	0.26 (0.18)	0.00	0.80
	PC duration (minutes)	25 (4)	0	416
	Caffeine (0-1)	.20 (.23)	0.00	0.71
	Alcohol (0-1)	.05 (.12)	0.00	0.22
	Tobacco (0-1)	.11 (.26)	0.00	0.90

Note: SHC = somatic health complaints; TST = total sleep time; BDI = Beck Depression Inventory; PC = perseverative cognition; the objective sleep quality is based on the fragmentation index

Table 2. Regression results for the testing of the main effects of self-reported total sleep time without mood (Model 1) and with mood (Model 2) on subjective health complaints (log-transformed) and of self-reported total sleep time on mood (Model 3), controlling for stressful events, PC duration, age, gender, caffeine consumption, alcohol consumption, tobacco consumption and depressive symptoms.

			Coeff. (*SE*)
Model 1	Subjective Health Complaints (log-transformed)		
		Self-reported total sleep time (hours)	-0.10 (0.03)***
		Stressful event (0-1)	0.59 (0.13)***
		PC duration (hours)	0.12 (0.04)**
		Age (years)	0.01 (0.02)
		Gender	0.27 (0.15)
		Caffeine (0-1)	0.20 (0.19)
		Alcohol (0-1)	-0.13 (0.33)
		Tobacco (0-1)	-0.27 (0.25)
		Depressive symptoms (0-63)	0.04 (0.01)**
		Intercept	1.63 (0.57)**
Model 2	Subjective Health Complaints (log-transformed)		
		Self-reported total sleep time (hours)	-0.08 (0.03)**
		Mood	-0.26 (0.06)***
		Stressful event (0-1)	0.44 (0.14)**
		PC duration (hours)	0.08 (0.04)
		Age (years)	0.01 (0.02)
		Gender	0.31 (0.15)*
		Caffeine (0-1)	0.07 (0.19)
		Alcohol (0-1)	-0.02 (0.32)
		Tobacco (0-1)	-0.19 (0.24)
		Depressive symptoms (0-63)	0.02 (0.01)
		Intercept	3.04 (0.64)***
Model 3	Mood (1-8)		
		Self-reported total sleep time (hours)	0.10 (0.02)***
		Stressful event (0-1)	-0.67 (0.12)***
		PC duration (hours)	-0.17 (0.03)***
		Age (years)	0.02 (0.03)
		Gender	0.21 (0.17)
		Caffeine (0-1)	-0.46 (0.16)**
		Alcohol (0-1)	0.47 (0.25)
		Tobacco (0-1)	0.40 (0.25)
		Depressive symptoms (0-63)	-0.08 (0.02)***
		Intercept	5.25 (0.61)***
	Estimated mediated part [95% confidence interval]		25% [13%; 61%]

Notes: PC = perseverative cognition; reference category for gender is men; ***$p < .001$, **$p < .01$, *$p < .05$

Table 3. Regression results for the testing of the main effects of objective total sleep time without mood (Model 1) and with mood (Model 2) on subjective health complaints (log-transformed) and of objective total sleep time on mood (Model 3), controlling for stressful events, PC duration, age, gender, caffeine consumption, alcohol consumption, tobacco consumption and depressive symptoms.

			Coeff. (*SE*)
Model 1	Subjective Health Complaints (log-transformed)		
		Objective total sleep time (hours)	-0.12 (0.03)***
		Stressful event (0-1)	0.58 (0.13)***
		PC duration (hours)	0.12 (0.04)**
		Age (years)	0.01 (0.02)
		Gender	0.29 (0.15)
		Caffeine (0-1)	0.17 (0.19)
		Alcohol (0-1)	-0.14 (0.33)
		Tobacco (0-1)	-0.28 (0.25)
		Depressive symptoms (0-63)	0.05 (0.01)**
		Intercept	1.64 (0.57)**
Model 2	Subjective Health Complaints (log-transformed)		
		Objective total sleep time (hours)	-0.10 (0.03)**
		Mood	-0.26 (0.06)***
		Stressful event (0-1)	0.42 (0.14)**
		PC duration (hours)	0.08 (0.04)
		Age (years)	0.01 (0.02)
		Gender	0.33 (0.15)*
		Caffeine (0-1)	0.04 (0.19)
		Alcohol (0-1)	-0.04 (0.33)
		Tobacco (0-1)	-0.19 (0.24)
		Depressive symptoms (0-63)	0.02 (0.01)
		Intercept	3.11 (0.64)***
Model 3	Mood		
		Objective total sleep time (hours)	0.11 (0.03)***
		Stressful event (0-1)	-0.66 (0.12)***
		PC duration (hours)	-0.17 (0.03)***
		Age (years)	0.02 (0.03)
		Gender	0.19 (0.17)
		Caffeine (0-1)	-0.41 (0.16)*
		Alcohol (0-1)	0.48 (0.25)
		Tobacco (0-1)	0.37 (0.25)
		Depressive symptoms (0-63)	-0.08 (0.02)***
		Intercept	5.30 (0.62)***
	Estimated mediated part [95% confidence interval]		22% [12%; 48%]

Notes: PC = perseverative cognition; reference category for gender is men; ***$p < .001$, **$p < .01$, *$p < .05$

Table 4. Regression results for the testing of the main effects of self-reported sleep quality without mood (Model 1) and with mood (Model 2) on subjective health complaints (log-transformed) and of self-reported sleep quality on mood (Model 3), controlling for stressful events, PC duration, age, gender, caffeine consumption, alcohol consumption, tobacco consumption and depressive symptoms.

		Coeff. (*SE*)
Model 1	Subjective Health Complaints (log-transformed)	
	Self-reported sleep quality (1-6)	-0.08 (0.03)**
	Stressful event (0-1)	0.50 (0.12)***
	PC duration (hours)	0.10 (0.04)**
	Age (years)	-0.01 (0.02)
	Gender	0.34 (0.14)*
	Caffeine (0-1)	0.04 (0.17)
	Alcohol (0-1)	0.11 (0.28)
	Tobacco (0-1)	-0.08 (0.22)
	Depressive symptoms (0-63)	0.04 (0.01)**
	Intercept	1.54 (0.54)**
Model 2	Subjective Health Complaints (log-transformed)	
	Self-reported sleep quality (1-6)	-0.05 (0.03)
	Mood	-0.25 (0.05)***
	Stressful event (0-1)	0.31 (0.13)*
	PC duration (hours)	0.06 (0.04)
	Age (years)	-0.00 (0.02)
	Gender	0.38 (0.14)**
	Caffeine (0-1)	-0.01 (0.17)
	Alcohol (0-1)	0.08 (0.28)
	Tobacco (0-1)	-0.12 (0.22)
	Depressive symptoms (0-63)	0.03 (0.01)
	Intercept	2.96 (0.61)***
Model 3	Mood	
	Self-reported sleep quality (1-6)	0.09 (0.02)***
	Stressful event (0-1)	-0.67 (0.11)***
	PC duration (hours)	-0.20 (0.03)***
	Age (years)	0.01 (0.02)
	Gender	0.17 (0.15)
	Caffeine (0-1)	-0.37 (0.15)*
	Alcohol (0-1)	0.10 (0.22)
	Tobacco (0-1)	-0.06 (0.22)
	Depressive symptoms (0-63)	-0.07 (0.01)***
	Intercept	5.88 (0.56)***
	Estimated mediated part [95% confidence interval]	30% [15%; 83%]

Notes: PC = perseverative cognition; reference category for gender is men; ***$p < .001$, **$p < .01$, *$p < .05$

Table 5. Regression results for the testing of the main effects of objective sleep quality (sleep fragmentation) without mood (Model 1) and with mood (Model 2) on subjective health complaints (log-transformed) and of objective sleep quality on mood (Model 3), controlling for stressful events, PC duration, age, gender, caffeine consumption, alcohol consumption, tobacco consumption and depressive symptoms.

		Coeff. (*SE*)
Model 1	Subjective Health Complaints (log-transformed)	
	Sleep fragmentation (0-100)	0.012 (0.003)***
	Stressful event (0-1)	0.57 (0.13)***
	PC duration (hours)	0.10 (0.04)**
	Age (years)	0.01 (0.02)
	Gender	0.27 (0.15)
	Caffeine (0-1)	0.20 (0.18)
	Alcohol (0-1)	0.10 (0.29)
	Tobacco (0-1)	-0.17 (0.23)
	Depressive symptoms (0-63)	0.05 (0.01)**
	Intercept	0.46 (0.55)
Model 2	Subjective Health Complaints (log-transformed)	
	Sleep fragmentation (0-100)	0.013 (0.003)***
	Mood	-0.31 (0.06)***
	Stressful event (0-1)	0.36 (0.13)**
	PC duration (hours)	0.05 (0.04)
	Age (years)	0.02 (0.02)
	Gender	0.33 (0.15)*
	Caffeine (0-1)	0.07 (0.18)
	Alcohol (0-1)	0.02 (0.28)
	Tobacco (0-1)	-0.12 (0.22)
	Depressive symptoms (0-63)	0.02 (0.01)
	Intercept	2.29 (0.62)***
Model 3	Mood	
	Sleep fragmentation (0-100)	0.002 (0.003)
	Stressful event (0-1)	-0.71 (0.11)***
	PC duration (hours)	-0.19 (0.03)***
	Age (years)	0.02 (0.03)
	Gender	0.23 (0.17)
	Caffeine (0-1)	-0.39 (0.15)*
	Alcohol (0-1)	-0.02 (0.22)
	Tobacco (0-1)	0.17 (0.22)
	Depressive symptoms (0-63)	-0.08 (0.02)***
	Intercept	5.87 (0.59)***

Notes: PC = perseverative cognition; reference category for gender is men; ***p < .001, **p < .01, *p < .05

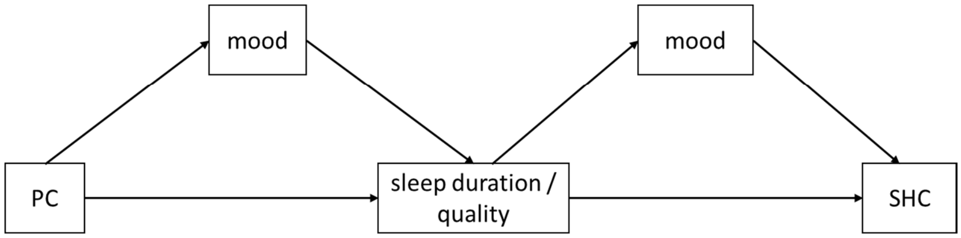

Figure 1: Suggested research model