ORIGINAL ARTICLE

APPLIED PSYCHOLOGY: Health and Well-Being | IAAP

Sleep and stress in times of the COVID-19 pandemic: The role of personal resources

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Abstract

There is still little research on the association between COVID-19-related stress and insufficient sleep. As distress is assumed to be high in these times, the role of personal resources becomes more important. The current study aimed to investigate the predictive role of COVID-19-related stress, positive affect, and self-care behavior for subjective sleep quality and sleep change measures since the outbreak of COVID-19 in Germany. A sample of 991 adults (M = 34.11 years; SD = 12.99) answered questionnaires during the first lockdown period in Germany and afterward (between April 1 and June 5, 2020). A higher stress level predicted lower sleep quality and more negative changes in overall sleep and pre-sleep arousal. Higher levels of positive affect and self-care predicted higher sleep quality and more positive changes in sleep. Analyses showed a moderation of positive affect on the association between stress and change in pre-sleep arousal. The improvement in personal resources, especially positive affect, in times of high stress seems relevant to overcome sleep problems. Future research should include objective measurements of sleep and longitudinal designs to uncover causal directions of effects.

INTRODUCTION

Sleep plays a major role in the context of health and well-being (Altena et al., 2020; Steptoe et al., 2008). In particular, in times of stressful life events, insufficient sleep is common (Li et al., 2019). The COVID-19 virus caused a worldwide pandemic. Several studies highlight that different pandemic-related stressors (e.g. social isolation, financial worries, health worries) are likely to cause increased distress and anxiety in the population and a higher number of people reporting a poor sleep quality (Ammar et al., 2021; Shapiro et al., 2020; Zhang et al., 2020). In addition, Zhao et al., (2020) revealed positive relations between perceived stress and sleep problems. Moreover, Liu et al., (2020) found that persons with better sleep quality reported lower levels of posttraumatic stress symptoms during COVID-19. These studies indicate the importance of throwing light on the association between stress symptoms and COVID-19-related sleep problems.

However, resources, including health-promoting attitudes and behaviors (Harfst et al., 2009), play a major role in managing and buffering stressful situations and promoting good health (Wong, 1993). This is why the conglomerate of resources, stress, and its relation to sleep as a component of health seems particularly meaningful in the time of COVID-19 as a potentially stressful life event. In line with this, a model of Pressman et al. (2019) assumes a predictive function of psychological resources for health behavior (e.g. sleep) and a moderating function for the association between stress and sleep. During the COVID-19 pandemic, the use of *personal* psychological resources to promote health is especially important, as the availability of *environmental/social* resources is limited due to quarantine measures and contact restrictions.

In this context, the construct of self-care as a personal resource for good health (e.g. sleep) may be important, since it includes all activities that contribute to health or its recovery being performed unaided by an individual (Orem, 2003). Unfortunately, there are diverse definitions used for the term of *self-care* (Riegel et al., 2019). Many of the previous studies emphasize the behavioral aspect in defining self-care (including specific strategies). According to Dorociak et al. (2017), self-care can be defined as "a multidimensional, multifaceted process of purposeful engagement in strategies that promote healthy functioning and enhance well-being" (p. 326). Some self-care measurement instruments involve components such as physical activity, nutrition, and stress management (Walker et al., 1987). According to Shapiro et al. (2007), self-care also includes strategies of self-regulation or coping, balancing self and others' interests, and being self-aware. However, the current study refers to self-care as a principle emphasizing "the active role of people in maintaining their own wellbeing" (Martínez et al., 2021, p. 1). This contains mindful behavior with oneself and one's own limits (Harfst et al., 2009) and focuses on the concept of mindfulness (Kabat-Zinn, 1994).

Previous research on self-care has mainly been conducted in patient samples (with reference to specific diseases) or caregivers (Casida et al., 2018; Shapiro et al., 2007). Nevertheless, especially in periods of crisis self-care behaviors should be investigated in the whole population as they might be useful for everyone.

So far, the relation between sleep and self-care has only been examined in terms of specific self-care strategies and not regarding the definition of a more global self-care concept as used in this study. Further, sleep has mostly been considered as a predictor for self-care behavior (e.g. Casida et al., 2018). A study by Di Benedetto et al. (2019) found healthy self-care behaviors went along with good

> **PRACTITIONER POINTS**
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> - Positive behavior and emotions (e.g. positive affect, self-care behavior) seem to be relevant in the context of sleep, especially in high-stress periods.
> - Prevention and early intervention should focus on the improvement in personal resources.
> - The topic of sleep and its promotion should be increasingly addressed in practice, especially in times of a pandemic.

sleep quality, suggesting that healthy self-care behavior might also promote good sleep. Moreover, Rupert and Dorociak (2019) showed a buffering effect of self-care on the association between the experience of stress and negative outcomes (i.e. burnout symptoms). Therefore, the predictive role of self-care (as mindful behavior with oneself) regarding sleep and the moderating role of self-care on the association between COVID-19-related stress and sleep are investigated in the present study.

Although self-care and positive affect are closely related (Kessing et al., 2014), positive affect tends to focus on the feelings that are subjectively evaluated as positive (such as happy, calm, excited; Moskowitz et al., 2017) as opposed to self-care, which tends to focus on the behavioral level. Therefore, the study at hand also examines positive affect as a further personal resource for good health (e.g. sleep) and its predicting effect on sleep, as well as the moderating effect on the association between stress and sleep. von Känel et al. (2014) showed a significant prediction of sleep quality by positive affect. Beyond, Steptoe et al. (2008) demonstrated that the strength of the association between psychological distress and sleep problems was reduced when including positive affect and well-being in the model. Further, a study by Pressman et al. (2017) highlighted the importance of positive affect in order to maintain healthy sleep, especially in high-stress periods. In line with this, Zhang et al. (2020) also assume that coping deficits (e.g. with regard to self-care and positive affect) might lead to higher levels of fear and anxiety in the context of COVID-19.

The current study aimed to examine the predictive and moderating role of positive affect, self-care behavior, and COVID-19-related stress for subjective sleep quality in a German sample (main research question). In addition, in exploratory models we examine the prediction of retrospective changes since the outbreak of COVID-19 in

a. overall sleep
b. pre-sleep arousal

by stress, self-care behavior, and positive affect (exploratory research questions).

METHODS

Participants and procedure

Participants were recruited via social media, local newspapers, and print flyers between April 1, 2020, and June 5, 2020, during the COVID-19 pandemic. Recruitment and data collection completely overlapped with the first lockdown in Germany including curfew and contact restrictions (beginning at March 22, 2020; German Federal Government, 2020a). This was also accompanied by school closures, closures of restaurants and service providers, distance restrictions (e.g. stay in public space

allowed only with one other person), and hygiene regulations (e.g. wearing mouth–nose protection since April 20, 2020; German Federal Government, 2020b). Some of the previously mentioned restrictions and requirements (e.g. contact and distance restrictions) were still maintained from May 6, 2020 (German Federal Government, 2020c), which is why the present study also includes a phase outside the strong lockdown in Germany.

In sum, 1,077 adult participants joined the study via an online-based survey and gave their informed consent. A minimum age of 16 years was required to participate in the study. The current study only included participants who stated to live in Germany at the time of the survey in order to avoid any bias from other COVID-19-related restrictions in other countries. Therefore, 86 participants were excluded from the analysis, and the final sample size was 991. The local ethics committee had no concerns about the study.

Measures

In addition to demographic variables, participants answered questionnaires on overall sleep quality, stress level due to COVID-19-related factors, own self-care strategies, and ability to experience positive affect. Two items also assessed changes in sleep since the outbreak of COVID-19.

Demographic variables

Participants were asked concerning age, gender (1 = *male*, 2 = *female*, 3 = *other*), relationship status, profession, and educational level.

Overall sleep quality

The adapted German version of the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989; Riemann & Backhaus, 1996) measures the subjective sleep quality retrospectively for the last 2 weeks. The 19 self-report items (i.e. "During the last two weeks, how often have you had trouble sleeping because you could not fall asleep within 30 minutes?") are mostly answered on a 4-point scale (from 0 = *not at all* to 3 = *three times or more per week*). Moreover, a total score was calculated ranging from 0 to 21, with higher values indicating more sleep problems or a lower overall sleep quality. A cutoff score (> 5) can distinguish participants who are good or poor sleepers (Buysse et al., 1989). In the present sample, 52% of the participants had a total score over 5, indicating poor sleep. The validity of the PSQI was confirmed in several previous studies (e.g. Buysse et al., 1989). Internal consistency for the total score was α = .75 (Hinz et al., 2017) for a community sample. In this study, Cronbach's alpha for the total score was .75.

Change in sleep variables

To measure specific changes in different sleep variables, two items were included to assess how overall sleep and pre-sleep arousal had changed retrospectively since the beginning of the pandemic, in contrast to the time before the outbreak of COVID-19. The items were answered on an 11-point scale. Regarding the overall sleep item, the scale ranged from −5 ("I sleep worse than before") to 0 ("I sleep in the same

way as before") to 5 ("I sleep better than before"). The item measuring changes in pre-sleep arousal could be answered from −5 ("I am more stressed before falling asleep than before") to 0 ("I feel like usual before falling asleep") to 5 ("I am more relaxed before falling asleep than before"). Therefore, higher and positive values indicated a positive change since the outbreak of the pandemic. In the analyses, the two items were used separately as measures of sleep changes since the outbreak of COVID-19.

Positive affect and self-care

The Hamburg Self-Care Questionnaire (HamSCQ; Harfst et al., 2009) is a 12-items instrument to measure self-care behavior and the acceptance and enjoyment of positive experience and behavior in the last 4 weeks. In the current study, we addressed the past 2 weeks so that all measurements referred to the same time period. The items are answered on a 5-point scale (from 1 = *not applicable at all* to 5 = *very applicable*). The HamSCQ contains the two subscales *Pacing* (six items) and *Positive Experience* (six items). *Pacing* includes specific mindful behavior with oneself and one's own limits (i.e. "I have allowed myself times of rest and relaxation" or "I arranged my days in a way that I was able to feel good."), which will be referred to in the following as *Self-Care Behavior*. In contrast, *Positive Experience* measures the extent to which someone can accept and enjoy positive experiences and behavior (i.e. "I was able to feel happy"). Therefore, in the following this subscale will be referred to as *Positive Affect*. In a clinical sample, the internal consistency was α = .93 (*Positive Affect*) and α = .90 (*Self-Care Behavior*; Harfst et al., 2009). In this study, Cronbach's alpha was .91 (*Positive Affect*) and .87 (*Self-Care Behavior*).

Stress level due to the COVID-19 pandemic

To the best of our knowledge, there is no previous questionnaire to assess pandemic-related stress, so the COVID-19 Pandemic Stress Scale (CPSS; Werner et al., 2021) was developed for this study. The questionnaire measures the subjective stress and anxiety level due to different aspects of the COVID-19 pandemic in the last 2 weeks. It contains 10 items (i.e. "How stressed/anxious have you felt in the last 2 weeks by the uncertain economic development in Germany and worldwide?") and is answered on a 4-point scale (from 0 = *not stressed at all* to 3 = *very stressed*). Participants were asked how stressed or anxious they had been due to hygienic behavior rules, behavior rules in the public sector (i.e. keeping distance), contact restrictions, media reports, fear of infection with COVID-19, fear that other people will be infected with COVID-19, other people's fears, uncertain economic development, closure of kindergartens, schools etc., and closure of (public) places. An exploratory factor analysis was carried out to check the factor structure of this questionnaire. A principal component analysis with varimax rotation was calculated. Based on the scree plot, a one-factor solution was preferred to be used for subsequent analyses and explained 30.79% of variance. The items constituting the one-factor solution were then summarized to a total stress score, ranging from 0 to 30, referred to as *COVID-19-related stress* in the following. The internal consistency was α = .74.

Statistical analysis

All analyses were executed with IBM SPSS Statistics version 26. Only those cases were included in the analysis that answered at least 70% of the items. Based on this condition, the mean value was

entered in the case of missing values and used to calculate the total score. Because the calculation of the PSQI total value can be performed only if values are available for each component, a sample of $n = 958$ was used for this analysis due to missing values. The exploratory research questions also used subsamples, because not all participants answered the items on the changes in sleep measures.

As preliminary analyses, Pearson's or Spearman's correlations (for categorical variables) were calculated. For the main research question, multiple linear hierarchical regression analyses with forced entry were computed to investigate whether COVID-19-related stress, positive affect, and self-care behavior might predict overall subjective sleep quality. In addition, it was analyzed whether the relationship between COVID-19-related stress and sleep quality is moderated by positive affect and self-care behavior. In the first step of the hierarchical regression, we controlled for relevant demographic variables. In a second step, the total score of COVID-19-related stress and the sub-scales *Positive Affect* and *Self-Care Behavior* were used as predictor variables. The total PSQI score was used as the criterion variable for this analysis. Furthermore, in a third step of the hierarchical regression analysis, interaction terms of all possible combinations of predictor variables were used to test potential moderating effects (stress*positive affect, stress*self-care, positive affect*self-care, stress*positive affect*self-care). It is assumed that the first variable of the interaction term is the predictor and the second (or in the case of a triple interaction, the two variables placed at the end) is the moderator. For the interaction of positive affect*self-care, no determination of predictor and moderator can be made.

To investigate the moderating effects, the stepwise method was used to statistically test the most important interaction terms and to achieve the smallest possible statistical model in the final analysis (Brace et al., 2012). All predictor variables (including the main and the interaction effects) were mean-centered before all analyses by subtracting the sample mean from the observed value for each participant. Accordingly, the interaction terms for moderation were also calculated with mean-centered values.

In the exploratory research questions, investigating the predictive role of COVID-19-related stress, positive affect, and self-care behavior for the change in different sleep measures, the criterion variable was substituted by the two variables that measure changes in sleep (i.e. overall sleep and pre-sleep arousal) in two additional regression analyses.

For all regression models, standardized regression coefficients are presented. All requirements for a multiple linear regression analysis and the normal distribution of all variables were checked in advance and were met unless otherwise stated. For all computations, a p-value $< .01$ was considered as significant. The goodness of fit is reported by R^2 and interpreted according to Cohen (1988). An R^2 of .02 means a low and weak, an R^2 of .13 means a moderate, and an R^2 of .26 indicates a high and strong explanation of variance. Further, the change in R^2 between the models is reported.

RESULTS

Descriptive statistics

The mean age of the sample was 34.11 years ($SD = 12.99$ years), and 67.7% of the participants were female (31.5% male, 0.8% other). The majority of the sample was in a relationship (39.3%) or married (28.1%). One third of the sample was single (33.3%). Almost half of the participants had a university degree (48.7%). Most participants were employees (52.3%). The sample also included 25.4% of students and 3.7% of pupils. The other participants were self-employed, retired, currently not working, or had a mini job.

TABLE 1 Mean values and standard deviations for the relevant variables

	M	*SD*
COVID−19-related Stress	23.63	5.10
Self-Care Behavior	20.85	4.73
Positive Affect	20.38	5.28
Overall Sleep Quality[a]	6.31	3.53
Overall Sleep Change[b]	−0.68	2.00
Pre-Sleep Arousal Change[c]	−0.63	1.92

The overall stress level can range from 0 to 30 with higher levels indicating more stress; the value of overall sleep quality (PSQI total score) can range from 0 to 21 with higher levels indicating lower sleep quality; self-care behavior and positive affect can range from 6 to 30; all change measures have a range of −5 to 5 with positive values indicating an improvement in overall sleep/pre-sleep arousal since the beginning of the pandemic (a value of −5 indicates the worst change in overall sleep/pre-sleep arousal).

$N = 991$;

[a]$n = 963$;

[b]$n = 942$;

[c]$n = 987$

Mean values and standard deviations for all variables can be found in Table 1. Regarding the change in sleep measures, the mean values show negative values indicating that on average the participants' sleep changed for the worse in comparison with the time before the outbreak of the pandemic. Most important, overall sleep changed negatively in comparison with the time before the pandemic in 43.8% of the participants. Of the participants, 41.6% reported higher negative pre-sleep arousal than before the COVID-19 outbreak.

Table 2 shows the percentages of participants who were strongly stressed/anxious by the COVID-19 situation (questionnaire answers with 3 = *very stressed*). Most of the participants reported a high stress level due to contact restrictions (34.1%).

Higher COVID-19-related stress was associated with lower self-care, positive affect, and poorer overall sleep quality as measured by the PSQI. Further, stress was correlated with a negative change in overall sleep and pre-sleep arousal. Moreover, female sex was associated with higher levels of stress, lower overall sleep quality, and higher positive affect. Being single, divorced, or widowed was associated with a lower positive affect and a lower overall sleep quality. A higher educational level was associated with a higher positive affect and self-care behavior, as well as a higher overall sleep quality. All in all, correlation analyses showed significant associations in the expected direction between all variables (see Table 3). In the following regression analyses, we controlled for the demographic variables including age, gender, educational level, and relationship status.

Main research question: prediction of overall sleep quality

As the hierarchical multiple regression analysis showed, the predictors COVID-19-related stress, positive affect, self-care behavior, and the interaction term between positive affect and self-care significantly predicted the overall sleep quality ($F_{(8,949)} = 51.25$, $p < .001$). The model and all coefficients are displayed in Table 4. The other interaction terms (stress*positive affect, stress*self-care, and stress*positive affect*self-care) were excluded by the stepwise procedure due to lack of additional explanation of variance. Thus, only four predictors out of seven remained in the model. As expected,

TABLE 2 Percentages of participants reporting a high stress level on individual CPSS items

	% of participants with a high stress level
Hygienic Behavior Rules	3.2
Behavior Rules in the Public Sector (i.e. keeping distance)	9.4
Contact Restrictions	34.1
Media Reports	20.0
Fear of Infection With COVID−19	6.3
Fear That Other People Will Be Infected With COVID−19	22.7
Other People's Fears	9.0
Uncertain Economic Development	17.9
Closure of Kindergartens, Schools, etc.	12.5
Closure of (Public) Places	17.8

Notes: $N = 991$; frequency data refer to questionnaire answers with 3 = *very stressed* in the COVID-19 Pandemic Stress Scale (CPSS).

TABLE 3 Pearson's and Spearman's correlations between all variables

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. COVID−19-related Stress									
2. Self-Care Behavior	−.18*								
3. Positive Affect	−.17*	.57*							
4. Overall Sleep Quality	.29*	−.43*	−.42*						
5. Overall Sleep Change	−.22*	.38*	.35*	−.54*					
6. Pre-Sleep Arousal Change	−.26*	.36*	.34*	−.48*	.72*				
7. Age	−.06	.02	−.01	−.03	.02	.02			
8. Gender	.23*	.02	.08*	.10*	−.01	−.05	−.19*		
9. Relationship Status	−.04	−.03	−.17*	.09*	.02	.03	−.24*	.02	
10. Educational Level	−.01	.10*	.12*	−.17*	.05	.05	.11*	.05	−.09*

Higher values on overall sleep quality indicate more sleep problems and a lower sleep quality; positive values on the change in sleep measures indicate a positive change in the respective variable (better overall sleep, less pre-sleep arousal); relationship status (1 = *married/in a relationship*; 2 = *single/widowed/divorced*); education level (with higher values indicating a higher level of education).

*$p < .01$.

a higher stress level predicted lower overall sleep quality ($\beta = .20$). In contrast, higher values on the two resources positive affect ($\beta = −.22$) and self-care behavior ($\beta = −.26$) predicted higher overall sleep quality.

The interaction meant that self-care and positive affect overlapped in their effects on overall sleep quality and therefore did not result in strictly summative effects.

Further, the gender effect ($\beta = .08$) and the effect of educational level ($\beta = −.10$) remained significant throughout the analysis. All in all, the whole model showed a high goodness of fit with an adjusted R^2 of .30 in the final step including all relevant variables (Table 4).

APPLIED PSYCHOLOGY: Health and Well-Being   IAAP

TABLE 4 Hierarchical regression analysis for the prediction of overall sleep quality

	B	SE(B)	β	p	ΔR²
Step 1					.045, p < .01
Age	0.00	0.01	.00	.93	
Gender	0.77	0.24	.10	<.01	
Educational Level	−0.59	0.11	−.18	<.001	
Relationship Status	0.42	0.24	.06	.08	
Step 2					.251, p < .001
Age	0.00	0.01	.00	.94	
Gender	0.62	0.22	.08	<.01	
Educational Level	−0.37	0.09	−.11	<.001	
Relationship Status	0.14	0.21	.02	.51	
COVID−19-related Stress	0.13	0.02	.19	<.001	
Positive Affect	−0.16	0.02	−.24	<.001	
Self-Care Behavior	−0.19	0.03	−.26	<.001	
Step 3					.005, p < .01
Age	0.00	0.01	.01	.81	
Gender	0.62	0.21	.08	<.01	
Educational Level	−0.34	0.09	−.10	<.001	
Relationship Status	0.17	0.21	.02	.41	
COVID−19-related Stress	0.14	0.02	.20	<.001	
Positive Affect	−0.15	0.02	−.22	<.001	
Self-Care Behavior	−0.19	0.03	−.26	<.001	
Positive Affect x Self-Care	0.01	0.00	.08	<.01	

Notes: Criterion variable: PSQI total score (higher scores indicate lower sleep quality); in step 3, all other interaction terms were excluded by the stepwise procedure; $n = 958$.

Exploratory research questions

Prediction of change in overall sleep

The hierarchical regression model for the prediction of overall sleep change since the outbreak of COVID-19 showed a significant effect for the predictors COVID-19-related stress, positive affect, and self-care behavior ($F_{(7,930)} = 31.88, p < .001$). All interaction terms were excluded by the stepwise method. Thus, only three predictors remained in the final model. The model showed a negative regression coefficient for the association between stress and overall sleep change ($\beta = -.14, p < .001$), indicating that higher stress levels predict a more negative change in the participants' self-perceived sleep quality during the pandemic compared with the time before. Higher levels of positive affect ($\beta = .20$, $p < .001$) and self-care behavior ($\beta = .24, p < .001$) predicted a more positive change in overall sleep. Because there were no additional moderating effects, this model is not displayed in more detail. The final model indicated a moderate explanation of variance with an adjusted $R^2 = .19$.

Prediction of change in pre-sleep arousal

Table 5 shows the results for the prediction of changes in pre-sleep arousal. A higher stress level predicted more negative changes in the participants' self-reported pre-sleep arousal ($\beta = -.18$). Regarding this, a negative change indicates a higher subjective pre-sleep arousal during the pandemic compared with the time before. A higher positive affect ($\beta = .19$) and self-care behavior ($\beta = .22$) were predictors for a more positive change of pre-sleep arousal (being less aroused before sleeping).

The significant interaction term stress*positive affect ($\beta = .09$) indicates that besides the additive effects of positive affect, self-care behavior, and stress, there is also a synergistic effect of stress and positive affect. All other interaction terms (positive affect*self-care, stress*self-care, and stress*positive affect*self-care) were excluded by the stepwise method, leaving four predictors out of seven in the final model.

All in all, the model showed a moderate to high goodness of fit (adjusted $R^2 = .20$) and was statistically significant ($F_{(8,973)} = 31.29, p < .001$).

DISCUSSION

The aim of this study was to investigate associations between COVID-19-related stress, personal resources (positive affect and self-care behavior), and sleep. In addition, retrospective changes in sleep measures since the beginning of the pandemic were considered. COVID-19-related stress significantly predicted sleep quality and sleep changes. Further, positive affect and self-care behavior were important predictors for overall sleep quality and changes in sleep variables.

A high percentage of participants was stressed or anxious due to contact restrictions under COVID-19 (34.1%). This is in line with results of Xiao et al. (2020) where low social capital was associated with higher levels of stress and anxiety in times of COVID-19. For good psychological health and low levels of stress, social contact or the feeling of belonging therefore seem to be relevant factors. The present study also underlined this assumption by revealing more positive affect and a higher overall sleep quality for participants in a relationship or marriage. In line with this, Saltzman et al. (2020) highlighted the importance of helping people to stay connected, especially in times of pandemics.

Gritsenko et al. (2020) showed that women have a greater fear of COVID-19 and related factors than men. In the current study, women also revealed significantly higher COVID-19-related stress levels than men.[1] Moreover, they also reported a lower overall sleep quality[2] and higher positive affect[3]. According to Yue et al. (2017), women possibly experience and express more emotions than men due to the cultivation of different social roles. This in turn might mean a more open and transparent communication of difficulties (e.g. sleep problems) and strengths (e.g. positive affect).

Regarding sleep quality, the mean PSQI was above the cutoff score of 5, indicating low sleep quality. Moreover, 52% showed a clinically relevant impaired sleep quality. In a study by Hinz et al.

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[1]The analysis of an independent *t*-test revealed the following result for COVID-19-related stress: *95%* CI [−3.31,-1.98]; $t_{(979)} = -7.80, p < .001$.

[2]The analysis of an independent *t*-test revealed the following result for PSQI total score: *95%* CI [−1.15,-0.19]; $t_{(953)} = -2.72$, *p* <.01.

[3]The analysis of an independent *t*-test revealed the following result for positive affect: *95%* CI [−1.95,-0.50]; $t_{(561.75)} = -3.32$, *p* <.01.

TABLE 5 Hierarchical regression analysis for the prediction of change in pre-sleep arousal

	B	SE(B)	β	p	ΔR²
Step 1					.006, p =.21
Age	0.00	0.01	.02	.61	
Gender	−0.08	0.13	−.02	.52	
Educational Level	0.13	0.06	.07	.02	
Relationship Status	0.06	0.13	.02	.64	
Step 2					.191, p < .001
Age	0.00	0.00	.01	.67	
Gender	0.00	0.12	.00	.99	
Educational Level	0.03	0.05	.02	.56	
Relationship Status	0.16	0.12	.04	.18	
COVID−19-related Stress	−0.07	0.01	−.19	<.001	
Positive Affect	0.07	0.01	.19	<.001	
Self-Care Behavior	0.09	0.01	.21	<.001	
Step 3					.008, p < .01
Age	0.00	0.00	.01	.66	
Gender	−0.01	0.12	.00	.97	
Educational Level	0.02	0.05	.01	.65	
Relationship Status	0.16	0.12	.04	.19	
COVID−19-related Stress	−0.07	0.01	−.18	<.001	
Positive Affect	0.07	0.01	.19	<.001	
Self-Care Behavior	0.09	0.01	.22	<.001	
Positive Affect × Stress	0.01	0.00	.09	<.01	

Criterion variable: change in pre-sleep arousal (positive values indicate less pre-sleep arousal in comparison with the time before the pandemic); in step 3, all other interaction terms were excluded by the stepwise procedure; $n = 982$.

(2017), only 36% of a German community sample met this criterion. However, in the study of Hinz et al. (2017) participants were part of the LIFE-Adult-Study, the mean age of $M = 56.3$ years was higher, and the gender ratio was more balanced (52% female) than in the current study. Accordingly, as previously discussed, the large proportion of women might be the reason for the open communication of sleep problems and the high prevalence score in the present study. Although no comparison can be made to the pre-pandemic period based on this PSQI value (52% with clinically relevant impaired sleep quality) from the current cross-sectional study, a study by Gupta et al. (2020) suggests a negative shift in several sleep measures compared with the pre-lockdown period. In the present study, all changes in self-assessed sleep measurements indicated a decrease in sleep quality and an increase in pre-sleep arousal compared with the time before lockdown, which is in line with a study by Cellini et al. (2020), where sleep difficulties increased during home confinement.

The regression model indicated a negative prediction of overall PSQI sleep quality by COVID-19-related stress. The importance of psychological and health-related stress in a pandemic was underlined by Peltz et al. (2020), who showed an association between this construct and lower perceived sleep quality in parents. As stress can be considered to be high in times of COVID-19 and due to (contact) restrictions, loneliness, and different forms of fear, it might be more relevant to enhance personal resources to buffer this negative effect.

In addition, our study showed that positive affect was positively associated with overall sleep quality. Previous research has already investigated the supporting effect of positive emotions (i.e. gratitude, optimism, positive affect) on the improvement in sleep quality (Jackowska et al., 2016).

Furthermore, self-care behavior was a predictor for higher sleep quality in the present study, which is in line with the results of Fu et al. (2020). Their study confirmed that no physical activity during the time of self-isolation was a risk factor for sleep disorders and passive coping. Trabelsi et al. (2021) also support this by showing the lowest score of sleep problems in people with high physical activity before and during home confinement. As self-care is a multidimensional construct with different facets, physical activity can also be seen as a behavior with linkage to self-care and stress management. Moreover, self-care is understood as a process of enhancing well-being and promoting healthy functioning (Dorociak et al., 2017) and might therefore also include strategies of adaptive coping in stressful situations. It therefore seems plausible that components of adaptive coping (i.e. self-care strategies) might predict sleep quality. Concerning this, a previous study found that adaptive coping strategies were predictive for acute stress disorders in times of COVID-19 (Ye et al., 2020). This finding might plausibly be transferred to the topic of sleep, because stress and sleep are closely related (Åkerstedt, 2006). The results in addition showed a synergistic effect of positive affect and self-care behavior regarding overall sleep quality. This goes beyond the summative effects of positive affect and self-care.

The results regarding the exploratory research questions indicate that stress functions as a predictor for changes in different sleep measures (overall sleep, pre-sleep arousal). In line with this, in the study of Cellini et al. (2020), the increase in sleep difficulties was stronger for higher stress symptomatology during the pandemic.

In the current study, positive affect and self-care behavior were significant predictors for the change in sleep measures, with higher levels of resources predicting a less negative change in all sleep measures. Regarding this, Mandelkorn et al. (2020) reported that reduced physical activity during the pandemic was associated with more severe worsening of sleep measures in adults. Due to the close connection between positive affect/self-care and physical activity (Pasco et al., 2011; Walker et al., 1987), the results of Mandelkorn et al. (2020) emphasize the findings of this study.

Further, a moderating effect of positive affect was found for the association between stress and the change in pre-sleep arousal. Thus, it might be assumed that positive affect buffers the negative effect of COVID-19-related stress on the change in pre-sleep arousal. It could be hypothesized that positive affect as a personal resource helps an individual to be more resistant to the negative consequences of stress during a pandemic. Grossman et al. (2020) also showed a moderating effect of resilience on the association between loneliness and sleep during the COVID-19 pandemic in older adults. In the current study, because self-care behavior did not play a role in all moderation analyses with stress as a second predictor, it may be assumed that positive affect might be more relevant for buffering the relation between stress and sleep in adulthood.

This study is the first to our knowledge to investigate possible associations among stress, sleep, and personal resources under the conditions of a pandemic in adults. Further, the present study extends research on specific self-care strategies to include a more global concept of self-care, which involves being mindful of one's self and one's limits, with relation to sleep in a pandemic situation. Moreover, the results include sleep change variables in comparison with the time before the outbreak of COVID-19. Another strength of the present study is the large sample size with a wide age range. There was, however, a recruitment bias resulting in a higher participation of women and young people. According to Smith (2008), the higher participation of women in online studies is not uncommon. There may be several reasons for this. One of them is that women use online activity more for communication and exchange, and men more for knowledge acquisition (Smith, 2008).

Further, the present sample held relatively high educational levels with almost 50% with a university degree. This is in contrast to the general distribution of education levels in Germany (17.6% with a university degree; German Federal Statistical Office, 2020). Concerning this, Fu et al. (2020) reported that a higher educational level was a risk factor for having a sleep disorder during the COVID-19 pandemic. However, in the current sample this finding could not be confirmed; educational level even was associated with a higher overall sleep quality, a higher positive affect, and a higher self-care behavior. Nevertheless, the sample is representative regarding relationship status in Germany (Statista, 2021).

As a limitation, however, all changes were assessed retrospectively and the study was based on a cross-sectional design. This limits the interpretation of the results. Therefore, no causal conclusions can be drawn regarding potential directions of effects. While it is likely that lower personal resources and higher stress might cause poor sleep, it is also conceivable that poor sleep leads to higher stress levels and a more difficult use of resources. It is also possible that there is a bidirectional relationship in the sense of a vicious circle. Future research should therefore focus on longitudinal studies investigating possible directions of effects.

Moreover, data collection overlapped with the time of the first lockdown and subsequent gradual reduction in restrictions. It is therefore unclear to what extent the results can be applied solely to a phase of a lockdown or to a phase outside a lockdown.

Another limitation is related to some small effect sizes, indicating that the large sample size could have led to significant effects, which might not have been significant in a smaller sample. Therefore, we adapted the significance level to $p < .01$.

One important restriction is also presented by the subjective sleep measurements in the current study. Further studies should therefore include objective and subjective measurements of sleep to investigate their consistency (Matthews et al., 2018) and validate the results of the current study for other data sources.

In summary, it can be said that especially in high-stress periods and times of a pandemic resulting in loneliness and contact restrictions, the consideration of personal resources such as positive affect and self-care behavior becomes more important. In particular, short online prevention programs enhancing positive affect and improving personal self-care behavior might be helpful.

The fact that previous studies showed a large part of the population suffering from depression, low well-being, and sleep problems during the COVID-19 pandemic (Ammar et al., 2020; Gupta et al., 2020) reveals the relevance of support by strengthening personal resources and sleep, which was also pointed out by the European Academy for Cognitive-Behavioral Treatment of Insomnia (Altena et al., 2020). In this regard, prevention and intervention, for example by using relaxation techniques and physical activity (Bentlage et al., 2020), should aim to promote personal resources. The implementation of positive psychological interventions (e.g. Three Good Things in Life; Claßen et al., 2017) might also improve sleep-quality and well-being including positive emotions during times of a pandemic. According to the broaden-and-build theory, experiencing positive emotions can also build enduring personal resources (e.g. self-care; Fredrickson, 2001). This could imply an antecedent function of positive affect for self-care behavior.

All in all, this study helps uncover relevant associations between stress resulting from the COVID-19 pandemic, sleep, and personal resources in adults. Important constructs were considered that could be of great relevance for sleep improvement. In particular, the enhancement of positive emotions in the context of highly stressful phases should play a special role in future research and practice.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ETHICAL APPROVAL

All procedures performed in this study were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Moreover, the study was approved by the ethics committee of Bielefeld University.

DATA AVAILABILITY STATEMENT

Data of the study are available by request from the first author.

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