Korean Journal of Clinical Psychology
2021. Vol. 40, No. 3, 235-244

Original Article

https://doi.org/10.15842/kjcp.2021.40.3.005
eISSN 2733-4538

The Relationship between Sleep Quality and Depressive Mood in University Students Experiencing Financial Difficulties: An Ecological Momentary Assessment Study

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This study aimed to examine the mediating effects of fatigue, stress, and affect on the relationship between sleep quality and depressive mood in university students experiencing financial difficulties. Participants (35) were university students in a metropolitan area of South Korea, recruited from September 2019 to December 2019 and from February 2020 to June 2020. They completed a pre-ecological momentary assessment online survey assessing sleep quality, fatigue, stress, and quality of life. Subsequently, participants participated in a 14-day ecological momentary assessment of daily depressive mood, sleep quality, fatigue, stress, and positive and negative affect. A multilevel mediation analysis indicated that fatigue completely mediated the relationship between sleep quality and depressive mood at the within- and between-subject levels, whereas stress and positive affect completely mediated the relationship only at the within-subject level. Negative affect did not mediate the relationship between sleep quality and depressive mood either at the within- or between-subject level. These findings suggest that interventions targeting mediators such as fatigue, stress and affect may alleviate the impact of poor sleep quality on depressive mood among university students experiencing financial difficulties.

Keywords: depression, ecological momentary assessment, financial difficulties, sleep quality, university students

Introduction

Depression is prevalent among university students with one-third of students having depression (Ibrahim, Kelly, Adams, & Glazebrook, 2013). Depression may lead to suicide risk (Dvorak, Lamis, & Malone, 2013), warranting clinical attention. In particular, depression needs to be considered in university students experiencing financial difficulties. According to social causation theory, social determinants (e.g., level of economic socioeconomic state etc) can affect mental health (Conger & Donnellan, 2007). For example, the experience of material hardship was associated with higher depression among 2,913 individuals with low-income in the Korean Welfare Panel Data (Kim, Shim, & Lee, 2016).

Sleep problems are considered a symptom of depression, but studies also suggest that sleep problems are a risk factor of depression (Baglioni et al., 2011). Among such problems, poor sleep quality is common in university students and was reported by more than 60% of college students (Lund, Reider, Whiting, & Prichard, 2010). Unlike sleep duration, poor sleep quality significantly predicted decreased physical and mental health in young adults (Muzni, Groeger, Dijk, Lazar, 2021). In fact, it was found that students with poor sleep quality were 1.52 times more likely to have depression than those with good sleep quality in a study with 617 college students (Ghrouz et al., 2019). In a study with 445 university students, the risk of depression was 3.28 times higher in students with

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Received Mar 11, 2021; Revised May 24, 2021; Accepted Jul 4, 2021

This research was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2018S1A5A2A01037181).
This article is based on the master's thesis of the first author from Pusan National University.

poor sleep quality (Çelik, Ceylan, Ünsal, & Çağan, 2019). In addition, students experiencing financial difficulties are more likely to combine schooling with work (Roksa & Velez, 2010) and thus are likely to experience a decrease in sleep quality. For example, work-school conflicts were negatively associated with sleep quality in 74 college students (Y. Park & Sprung, 2015). Similarly, increased work hours were associated with deteriorated sleep quality, which affected an increase in depressive mood in a study with 792 university students (Peltz, Bodenlos, Kingery, & Rogge, 2020). However, the relationship between sleep quality and depression and mechanisms underlying their association are relatively under-studied in low-income students.

A prior review suggested that depression has a multifaceted etiology such as environmental, psychological and biological factors. Lifestyle factors (i.e., sleep, diet, physical activity) influence biological processes (e.g., immuno-inflammation, hypothalamic-pituitary adrenal axis imbalances, neurotransmitters imbalances etc), leading to depression (Lopresti, Hood & Drummond, 2013). Sleep quality was associated with fatigue (Bouwmans, Bos, Hoenders, Oldehinkel, & De Jonge, 2017; Doerr et al., 2015), stress (Bassett, Lupis, Gianferante, Rohleder, & Wolf, 2015; Yuan, Anya, & Guanling, 2018) and affect (Fung, Nguyen, Moineddin, Colantonio, & Wiseman-Hakes, 2014; Galambos, Dalton, & Maggs, 2009; Simor, Krietsch, Köteles, & McCrae, 2015). In addition, fatigue (Lee & Giuliani, 2019), stress (Berk et al., 2013) and affect (Pressman & Cohen, 2005) influenced biological processes, so they may be factors underlying the relationship between sleep quality and depression. In fact, in a 5-day ecological momentary assessment (EMA) study with university students, poor sleep quality predicted greater fatigue (Doerr et al., 2015). Fatigue, in turn, may cause a negative change in mood (Techera, Hallowell, Stambaugh, & Littlejohn, 2016), which lead to depression (Wong, Zhang, Wing, & Lau, 2017). To illustrate, fatigue partially mediated the relationship between sleep quality and negative affect (NA) in depressed and healthy individuals (Bouwmans et al., 2017).

Studies have identified that stress is associated with sleep quality and depression. For example, perceived stress partially mediated the relationship between sleep quality and depression among college nursing students (Yuan et al., 2018). Moreover, among university students and community members, those with poor sleep quality showed stronger cortisol stress responses (Bassett et al., 2015). Furthermore, a higher stress level was associated with an increase in depression in a study with 800 university students (Schofield, O'Halloran, McLean, Forrester-Knauss & Paxton, 2016).

Furthermore, a review of the relationship between sleep and emotion suggests that affect plays a mediating role in a pathway through which sleep influences depression (Banglioni Spiegelhalder, Lombardo, & Riemann, 2010). Sleep quality can lead to seeing things from positive perspective (Galambos et al., 2009). Thus, sleep quality may be associated with positive affect (PA) and negative affect (NA). In fact, good sleep correlated with positive affect (PA) while poor sleep correlated with negative affect (NA) in young adults (Fung et al., 2014). Similarly, deteriorative sleep quality was associated with decreased PA and increased NA (Simor et al., 2015). Moreover, both PA and NA were related to increased depression (Parrish, Cohen, & Laurenceau, 2011; Raes, Smets, Nelis, & Schoofs, 2012).

Although previous studies suggested potential mediating effects of fatigue, stress and affect in the sleep quality-depression relationship, most of them were cross-sectional studies using retrospective reports, which may cause recall bias. An EMA is a method that uses repeated collection of real-time data on individuals' behaviors and experiences in their environments, minimizing recall bias (Shiffman, Stone, & Hufford, 2008). It also allows to consider variation in sleep quality, stress, fatigue and affect over time (Bouwmans et al., 2017; Doerr et al., 2015; Simor et al., 2015).

Thus, this study examined the mediating roles of fatigue, stress, PA, and NA on the relationship between sleep quality and depressive mood in university students experiencing financial difficulties using EMA. In doing so, this study focused on economically disadvantaged university students as low socioeconomic status or income may increase a risk of depression in university students (Farrer, Gulliver, Bennett, Fassnacht, & Griffiths, 2016).

Methods

Participants and procedures

Participants comprised university students in a metropolitan area of South Korea; they were recruited from September 2019 to December 2019 and from February 2020 to June 2020. The inclusion

https://doi.org/10.15842/kjcp.2021.40.3.005

criteria were as follows: participants were those on (a) national basic livelihood security program (i.e., not enough income to meet their needs such as medical aid, housing, and education benefits), near-poverty groups (i.e., median income of 50 percent or less, but not national basic livelihood security recipients), or within the 1st (KRW 1,384,061 or less, equivalent to USD 1237.50)–3rd income decile (KRW 3,229,475 or less, equivalent to USD 2887.51) in South Korea, and (b) who could use the EMA application. Participants at high suicide risk (Mini-plus ≥ 10) (Sheehan et al., 1998) were excluded for ethical reasons.

A pre-EMA online survey included questionnaires regarding depression, sleep quality, fatigue, life stress, and quality of life (QOL). EMA was conducted for 14-days and consisted of a once-a-day event-based survey and a twice-a-day time-based survey. The event-based sampling is a data collection method in which predefined events are recorded each time they occur (Shiffman et al., 2008). In this study, the event-based survey included items assessing previous day's sleep. Participants received a notification about the event-based survey at 8:30 A.M. If participants did not complete the survey, they received a reminder signal after 2-hour. Regarding the time-based survey, data were collected based on a time schedule (Shiffman et al., 2008). The time-based survey included items assessing depressive mood, fatigue, stress, PA, and NA. The time-based survey was prompted at a random time within two time-window: (a) 9:00 A.M.–12:00 P.M. and (b) 5:00 P.M.–8:00 P.M. If they did not answer the questionnaires, a reminder was given via their mobile phone after an hour and half. Participants could respond to the time-based survey within 2-hour after the first notification went off.

Participants received a compensation worth KRW 20,000 (equivalent to USD 17.94) for their participation. If they completed more than 80% of EMA surveys, they received an additional compensation worth KRW 5,000 (equivalent to USD 4.48). This study was approved by the Pusan National University Institutional Review Board (PNU IRB/2019_92_HR).

Measures

Pre–EMA online survey

Depression was assessed using the Patient Health Questionnaire-9 (PHQ-9; S. J. Park, Choi, Choi, Kim, & Hong, 2010). The PHQ-9 comprises 9-item based on the DSM-Ⅳ criteria for depressive disorders; participants rated each item on a 4-point Likert scale (0: not at all–3: nearly every day). The total score ranged from 0 to 27 and was divided into the following severity categories: minimal (0–4), mild (5–9), moderate (10–14), moderately severe (15–19), and severe (20 or greater; Kroenke, Spitzer, & Williams, 2001). The Cronbach's α of the PHQ-9 was .81 (S. J. Park et al., 2010).

Sleep quality was assessed using the Korean version of the Pittsburgh Sleep Quality Index (PSQI-K; Sohn, Kim, Lee, & Cho, 2012). The PSQI-K comprises 18-item that measure sleep quality, sleep onset latency, sleep duration, sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction. The score of each question ranged from 0 to 3, and the total score ranged from 0 to 21, with higher scores indicating poorer sleep quality. The Cronbach's α of the PSQI-K was .84.

Fatigue was assessed using the 11-item Korean version of the Chalder Fatigue Scale (K-CFQ; Ha, Jeong, Hahm, & Shim, 2018). The CFQ is a two-factor model (physical and mental fatigue; Cella & Chalder, 2010), whereas the K-CFQ comprises three-factor (physical fatigue, mental fatigue, low energy). Items were rated on a 4-point Likert scale (0: less than usual–3: much more than usual). The total score ranged from 0 to 33, with higher scores indicating a severe level of fatigue. The Cronbach's α of the K-CFQ was .73–.87 (Ha et al., 2018).

Stress was evaluated with the Revised Life Stress Scale for College Students (RLSS-CS; Chon, Kim, & Yi, 2000). The RLSS-CS comprises 50-item with eight life stress areas (friends, lover, family, faculty, grade, economy, future, value). Items were rated on a 4-point Likert scale (0: never–3: frequent). The Cronbach's α of the RLSS-CS was .58-.77.

Quality of life was evaluated with the Korean version of the World Health Organization Quality of Life Scale study assessment instrument-BREF (Korean version of WHOQOL-BREF; Min et al., 2002). The Korean version of the WHOQOL-BREF included 26-item regarding global QOL and four QOL domains (physical health, psychological health, environment, social relationship). The potential scores for all domains ranged from 4 to 20, with higher scores indicating better QOL. The Cronbach's α of the Korean version of WHOQOL-BREF was .58–.77 (Min, Lee, Kim, Suh, & Kim, 2000).

Demographic information included participants' age, gender,

religion, grade, income decile, part-time job status, and work hours for a week.

EMA

Daily depressive mood, fatigue, and stress were assessed using an item of the visual-analogue scale. The potential score ranged from 0 (not at all) to 10 (severe).

Sleep was evaluated using a translated version of the consensus sleep diary (Carney et al., 2012). The consensus sleep diary comprises 9-item: (1) What time did you get into bed? (2) What time did you try to go to sleep? (3) How long did it take you to fall asleep? (4) How many times did you wake up, not counting your final awakening? (5) In total, how long did these awakenings last? (6) What time was your final awakening? (7) What time did you get out of bed for the day? (8) How would you rate the quality of your sleep? (9) Comments. Item 8 (perceived sleep quality) was assessed on a 5-point Likert scale (1: very poor–5: very good).

PA and NA were assessed using the Korean version of the Positive Affect and Negative Affect Schedule (K-PANAS; H. S. Park & Lee, 2016). The K-PANAS comprises two 10-item mood scales that measure PA and NA. Each item was rated on a 5-point Likert scale ranging from 1 (not at all) to 5 (extremely), and the total score for both PA and NA ranged from 10 to 50. The Cronbach's α of the K-PANAS was .81–.86.

Statistical analyses

A *t*-test, chi-square test, and Mann-Whitney *U* test were performed to identify group differences in demographic and study variables between students with and without financial difficulties using SPSS 25.0.

EMA data are intensive longitudinal data that are hierarchically nested and generated by repeated measures over time (Bolger & Laurenceau, 2013). Therefore, multilevel mediation analysis was used to identify the mediating effects of study variables on the sleep quality-depressive mood relationship using HLM 8.0. If independent, dependent variables, and mediator involved in the mediation model are assessed at level-1(within-subject level), the model is labeled as 1-1-1 (Preacher, Zyphur, & Zhang, 2010). In this study, sleep quality; depressive mood; and fatigue, stress, PA, NA were measured at level-1. Thus, a 1-1-1 model (Preacher et al., 2010) was performed (Table 1).

Table 1. *1-1-1 Multilevel Mediation Model*

Steps	Level	Models
1	1	$Y_{ij}=\beta_{0j}+\beta_{1j}(X_{ij}-X_{\bullet j})+r_{ij}$
	2	$\beta_{0j}=\gamma_{00}+\gamma_{01}(X_{\bullet j})+u_{0j}$
		$\beta_{1j}=\gamma_{10}$
2	1	$M_{ij}=\beta_{0j}+\beta_{1j}(X_{ij}-X1_{\bullet j})+r_{ij}$
	2	$\beta_{0j}=\gamma_{00}+\gamma_{01}(X_{\bullet j})+u_{0j}$
		$\beta_{1j}=\gamma_{10}$
3	1	$Y\_ij=\beta_{0j}+\beta_{1j}(X_{ij}-X_{\bullet j})+\beta_{2j}(M_{ij}-M_{\bullet j})+r_{ij}$
	2	$\beta_{0j}=\gamma_{00}+\gamma_{01}(X_{\bullet j})+\gamma_{02}(M_{\bullet j})+u_{0j}$
		$\beta_{1j}=\gamma_{10}$
		$\beta_{2j}=\gamma_{20}$

†. X: sleep quality, M: fatigue/stress/PA/NA, Y: depressive mood.

Moreover, depressive mood, fatigue, stress, PA, and NA were measured twice a day, whereas sleep quality was measured once a day. Therefore, we calculated the daily mean levels of depressive mood, fatigue, stress, PA, and NA. In addition, level-1 variables were group-mean centered, and grand-mean centered level-1 variables were used as level-2 (between-subject level) variables to decompose within- and between-subject effects (Bolger & Laurenceau, 2013). Multiple imputation was used to handle missing data. Further, the Monte Carlo confidence interval was performed to examine the mediating effects (Preacher et al., 2010) using MASS package in R (Selig & Preacher, 2008).

Results

Participants' characteristics

A total of 82 students participated in the pre-EMA online survey. The mean age was 20.72 ($SD=1.78$). A majority of the participants were female ($n=58$), sophomores ($n=32$), had no religion ($n=59$), and had worked more than one part-time job ($n=68$). Students with financial difficulties reported significantly longer weekly work hours compared to those without financial difficulties: Mann-Whitney $U=302.50$, $p<.01$. Students with financial difficulties worked an average of 15.24 ($SD=9.33$) hours a week, whereas those without financial difficulties did an average of 5.33 ($SD=5.22$) hours a week.

Mental fatigue, economic stress, and environment QOL significantly differed between students with and without financial diffi-

https://doi.org/10.15842/kjcp.2021.40.3.005

culties. Students with financial difficulties reported higher levels of psychological fatigue and economic stress compared to those without financial difficulties, psychological fatigue: Mann-Whitney $U = 175.00$, $p < .05$; economic stress: Mann-Whitney $U = 124.00$, $p < .001$. Environment QOL was lower in those with financial difficulties than those without, $t = -2.26$, $p < .05$. On the other hand, depression, sleep quality, total fatigue, life stress of college students, and QOL did not differ between students with and without financial difficulties.

Participants who did not meet the eligibility criteria regarding income decile ($n = 18$) or had high suicide risk ($n = 8$) were excluded from the EMA. Seventeen students further declined to participate after an explanation regarding the EMA procedure. Excluding four participants who did not complete the EMA, the final sample comprised 35 participants. The mean age was 20.91($SD = 1.95$). Most students were female ($n = 26$), sophomores ($n = 15$) and had no religion ($n = 26$). All but one student had part-time jobs, and they worked an average of 14.33 ($SD = 8.90$) hours a week.

EMA completion rate

The students completed 85.51% of sleep diary items and 72.40% of daily depressive mood, fatigue, stress, PA and NA items over 14-days. Twenty-two participants (62.86%) had a compliance rate over 80%.

Sleep quality and depressive mood: mediating effects of fatigue, stress, PA, and NA

Sleep quality and depressive mood

In EMA, intraclass correlation coefficient (ICC) was 0.58 [ICC = between-subject variation/within-subject variation+between-subject variation) = 290.25/(290.25+208.82)]. This indicated that 58% of the total variance regarding depressive mood was explained by between-subject variables.

Poor sleep quality the previous night significantly predicted an increase in depressive mood the next day, $\gamma_{10} = -2.89$, $p < .05$.

Sleep quality and depressive mood: the mediating effect of fatigue

An examination of the mediating effect of fatigue (Figure 1) revealed that the 95% confidence interval (CI) did not include 0, 95% CI [-4.49, -1.52], and that the direct effect of sleep quality on depressive mood was not significant at the within-subject level, $\gamma_{10} = 0.18$, $p = .87$. This therefore indicates that fatigue completely mediated the relationship between sleep quality and depressive mood at the within-subject level. Specifically, poor sleep quality the previous night predicted greater fatigue the next day, and greater fatigue was significantly related to increased depressive mood the next day.

At the between-subject level, the 95% CI ranged from -18.52 to -2.76 and did not include 0. And the direct effect of sleep quality on depressive mood was not significant, $\gamma_{01} = -1.27$, $p = .75$. This indicates that fatigue completely mediated the relationship between sleep quality and depressive mood also at the between-subject level. On days when people had poorer-than-average sleep quality, they reported higher-than-average fatigue, that led to increased depressive mood.

Sleep quality and depressive mood: the mediating effect of stress

An examination of the mediating effect of stress (Figure 2) revealed that the 95% CI did not include 0, 95% CI [-4.00, -0.56], and that the direct effect of sleep quality on depressive mood was not sig-

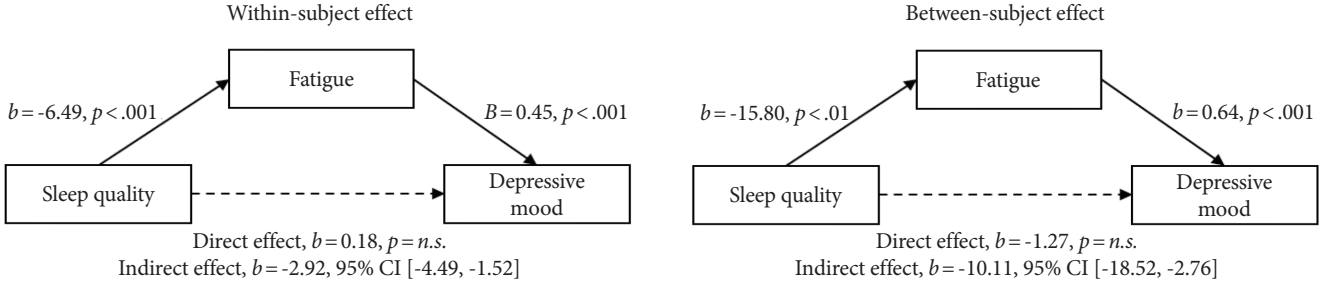

Figure 1. *Mediating effect of fatigue at the within- (left) and between-subject level (right).*

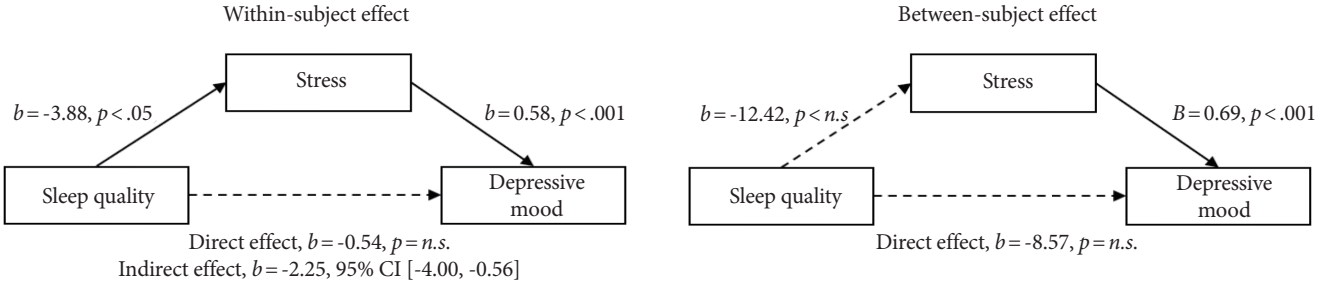

Figure 2. *Mediating effect of stress at the within- (left) and between-subject level (right).*

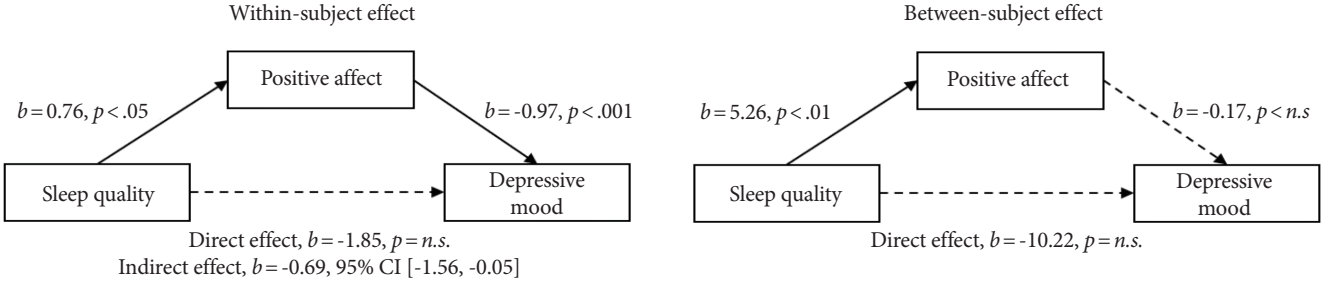

Figure 3. *Mediating effect of PA at the within- (left) and between-subject level (right).*

nificant at the within-subject level, $\gamma_{10} = -0.54$, $p = .56$. This indicates that stress completely mediated the sleep quality-depressive mood relationship at the within-subject level. Poor sleep quality at the previous time point predicted higher stress at the next time point, and higher stress was significantly related to increased depressive mood at the same time point.

At the between-subject level, sleep quality was not significantly associated with stress; therefore, the mediating effect of stress was not examined.

Sleep quality and depressive mood: the mediating effect of affect

An examination of the mediating effect of PA (Figure 3) revealed that the 95% CI ranged from -1.56 to -0.05 and did not include 0, and the direct effect of sleep quality on depressive mood was insignificant at the within-subject level, $\gamma_{10} = -1.85$, $p = .12$. This implies that PA completely mediated the sleep quality-depressive mood relationship at the within-subject level. Poor sleep quality the previous night significantly predicted decreased PA the next day, and decreased PA was associated with increased depressive mood the next day.

The relationship between PA and depressive mood was insignificant at the between-subject level, $\gamma_{02} = -0.17$, $p = .74$; thus, the mediating effect of PA was not examined.

On the other hand, sleep quality did not significantly predict NA at both the within- and between-subject level, within-subject level: $\gamma_{10} = -0.41$, $p = .24$; between-subject level: $\gamma_{01} = -0.06$, $p = .97$; thus, the mediating effect of NA was not examined.

Discussion

This study examined whether fatigue, stress, PA, and NA mediate the relationship between sleep quality and depressive mood in university students experiencing financial difficulties using EMA. Results indicated that poor sleep quality at the previous time point significantly predicted increased depressive mood at the next time point. A previous study with university students experiencing financial strain observed that longer work hours were associated with poor sleep quality, which in turn led to more depressive symptoms (Peltz et al., 2020). Poor sleep could induce biological processes such as immuno-inflammation and hypothalamic-pituitary adrenal imbalances; thus, poor sleep quality might influence increased depression (Lopresti et al., 2013).

With regard to the mediating effect of fatigue on the relationship

https://doi.org/10.15842/kjcp.2021.40.3.005

between sleep quality and depressive mood, fatigue completely mediated the relationship between sleep quality and depressive mood at both the within- and between-subject levels. Individuals with poor sleep quality at the previous time point reported higher fatigue at the next time point, and those with higher fatigue reported increased depressive mood. Poorer-than-average sleep quality also mediated the sleep quality-depressive mood relationship. Combining work with schooling, students experiencing financial difficulties might have sleep problems (Güneş & Arslantaş, 2017; Mason et al., 2018), and these sleep problems could lead to fatigue. For example, work-school conflict positively predicted fatigue in college student workers (Y. Park & Sprung, 2015).

Stress also completely mediated the sleep quality-depressive mood relationship at the within-subject level. Poor sleep quality at a previous time point predicted higher stress levels at the next time point, which, in turn, predicted increased depressive mood. This finding was consistent with a previous study of 242 nursing students (Yuan et al., 2018). Emotion regulation could help to understand the mediating effect of stress on the relationship between sleep quality and depressive mood. Poor sleep quality might lead to dysfunctional emotion regulation and decreased psychological resources (Baglioni, Spiegelhalder, Lombardo, Riemann, 2010), and maladaptive emotion regulation and stress coping could lead to depression (Hofmann, Sawyer, Fang, & Asnaani, 2012; Moriya & Takahashi, 2013).

Regarding the mediating effect of affect, PA completely mediated the sleep quality-depressive mood relationship at the within-subject level, whereas NA did not mediate the relationship either at the within- or between-subject levels. These findings are inconsistent with studies that reported that sleep quality was negatively associated with NA (Fung et al., 2014; Simor et al., 2015) and that higher NA predicted increased depressive symptoms (Parrish et al., 2011; Raes et al., 2012). One possible explanation is that sleep quality is more strongly related to PA than to NA. In fact, one study found that sleep quality was a robust predictive variable of PA but not NA (Bower, Bylsma, Morris, & Rottenberg, 2010). A third variable, such as PA, might influence the sleep quality-NA relationship. For example, in a 56-day EMA study with 552 adults, PA significantly buffered the negative effect of NA on stress (Blaxton, Bergeman, Whitehead, Braun, & Payne, 2017). This suggests that PA could moderate the sleep quality-NA relationship.

Of note, in the pre-EMA survey, students with financial difficulties reported higher mental fatigue, financial stress, and lower environmental QOL. Students with financial difficulties are more likely to combine schooling with work (Roksa & Velez, 2010); thus, they are likely to experience greater fatigue. Also, students experiencing financial difficulties may experience higher financial stress regarding expenses incurred in their higher education setting. This financial strain could affect perceived stress in university students (Adams, Meyers, & Beidas, 2016). Lastly, as students with financial difficulties may be economically burdened, they are more likely to live in an unsafe physical environment (Braubach & Fairburn, 2010).

These results suggest that interventions targeting fatigue, stress, and PA may alleviate the detrimental effect of poor sleep quality on depressive mood among university students experiencing financial difficulties. Specifically, fatigue mediated the relationship between sleep quality and depressive mood at both the within- and between-subject levels. These results suggest that cognitive behavioral therapy for insomnia (CBT-I) can be an effective intervention. In fact, CBT-I not only reduced sleep problems (i.e., sleep quality, sleep efficiency, and dysfunctional beliefs about sleep) and depressive symptoms (Cunningham & Shapiro, 2018) but also decreased the level of fatigue (Taylor et al., 2014). In addition, fatigue, stress, and PA mediated the sleep quality-depressive mood relationship at the within-subject level while mediating the effects of stress, and PA was not significant at a between-subject level. Between-subject effects are considered to have more generalized (i.e., trait) effects, and within-subject effects are characterized as more situational (i.e., state) (Cano et al., 2014). This implies that timely intervention when individuals experience fatigue, stress or decreased PA may be helpful to reduce depressive mood. An ecological momentary intervention (EMI) can be another feasible option to alleviate daily depressive mood. EMI has the advantage of providing timely intervention in a daily environment. Moreover, EMI can be a time-efficient and cost-effective way of intervening (Heron & Smyth, 2010).

This study has several limitations. First, subjective sleep quality was assessed. Despite the established high correlation between subjective and objective estimates of sleep (Grutsch et al., 2011), objective indicators of sleep should be included. Second, this study

assessed in-the-moment sleep quality, fatigue, stress, and depressive mood using a single item in order to promote response burden, which may not have provided a comprehensive measurement of variables. Third, the sample size was relatively small, possibly leading to low statistical power, which may have led to the detection of a potentially significant effect.

Despite these limitations, this study examined the mediating role of fatigue, stress, PA, and NA in the sleep quality-depression relationship, by separating within- and between-subject effects, in university students experiencing financial difficulties.

Author contributions statement

Eun-Jung Shim, professor at Pusan National University, and Eun Jung Yang, graduate student at Pusan National University, conducted the study and drafted the manuscript. Eun Jung Yang performed statistical analyses. All authors approved the final script.

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