Abstract: Sleep disorders persist in renal transplant patients. Previous studies have shown that fatigue and rumination are important determinants of sleep quality. However, very few studies have explored the mediating role of rumination in the relationship between fatigue and sleep quality in kidney transplant recipients. A descriptive cross-sectional research design was implemented, and 192 kidney transplant patients completed the short questionnaire about their recent experiences of fatigue, rumination, and sleep quality. The prevalence of sleep disorders among kidney transplant recipients was 19.3%. With rumination as a partial mediator, fatigue indirectly affected the patients’ sleep quality. This indirect effect was 0.10 (95% confidence interval, 0.154–0.419). Our results indicate that the incidence of sleep disorders after renal transplantation was high, and the more tired kidney transplant recipients become, the more likely they are to ruminate, which leads to a decline in sleep quality.

Key Words: Kidney transplantation, fatigue, sleep quality, rumination

METHODS

Study Design, Participants, and Data Collection

This study aimed to investigate the prevalence of sleep disorders among kidney transplant patients who were reexamined at outpatient departments. Furthermore, it explored the possible mediating role of rumination between fatigue and sleep quality. A convenience sample of 192 kidney transplant recipients who were reexamined at outpatient departments were recruited in three first-class hospitals from April to

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Association Between the Fatigue and Sleep Quality of Kidney Transplant Recipients

The Mediating Role of Rumination

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For patients with kidney failure, renal transplantation is more effective at prolonging patients’ life expectancy and improving their health-related quality of life, when compared with dialysis (Liaveri et al., 2017). However, studies indicate that patients’ existing sleep disorders (e.g., restless leg syndrome, sleep hypopnea, and sleep apnea) were not alleviated after kidney transplants (Burkhalter et al., 2013; Eslami et al., 2014), and their quality of sleep was lower than that of general patients (Xie et al., 2018). Hasanzamani et al. (2020) recorded patients’ sleep quality before, 3 months after, and 6 months after their renal transplants, and the data revealed that patients’ incidences of sleep disorders were 37.5%, 37.5%, and 20.0%, respectively (Hasanzamani et al., 2020). Furthermore, Xie et al. (2018) determined that the incidence of sleep disorders among Chinese kidney transplant recipients was 29.2% (Xie et al., 2018), which was much higher than the prevalence (15%) in the general healthy population (Cao et al., 2017). Sleep disorders can lead to daytime sleepiness and a decline in life function, which is not only harmful to patients’ physical, psychological, and social health but also negatively affects their cognitive functioning, behavior, and attention (De Pasquale et al., 2020; Eslami et al., 2014; van Sandwijk et al., 2019). Therefore, it is imperative to identify the risk factors associated with poor sleep quality and the rehabilitation mechanisms that can improve patients’ quality of daily life.

Fatigue is a subjective feeling of being overwhelmingly and continuously exhausted (Gregg et al., 2021). Furthermore, it is a decline of normal physical and mental strength levels that is closely related to various acute and chronic diseases (Tucker and Miguel, 1996). Although renal transplants significantly improve the quality of life of patients with end-stage renal disease, related reports revealed that 39% to 59% of the recipients still experience a higher level of fatigue (Chan et al., 2013; Goedendorp et al., 2013). In addition, several studies indicated that behavioral-psychosocial factors are directly related to fatigue. Bossola et al. (2016) discovered that fatigue and negative emotions (such as depression) are factors that strongly influence the sleep disorders of patients who received renal transplants (Bossola et al., 2016). Another study suggested that sleep disorders were prominent risk factors of fatigue (Goedendorp et al., 2013), which denoted the close association between fatigue and sleep disorders.

Rumination is a kind of negative cognitive style that occurs when encountering negative events (Marin and Rotondo, 2017). It entails continuous negative thoughts about the events themselves and the possible ensuing consequences, instead of constructive problem-solving actions (Slavish and Graham-Engelnd, 2015). This negative cognitive style is associated with increases in negative emotions and the decreased inhibitory control of negative information. Subsequently, this results in stable negative emotional patterns that lead to adverse health consequences, such as impaired sleep and weakened health (Joomrnand and Gotlib, 2010; Slavish and Graham-Engelnd, 2015). The microanalysis model of insomnia indicates that excessive wakefulness is the main cause of insomnia (Feige et al., 2013). This wakefulness is characterized by bedtime arousal, which consists of cognitive and physical arousal; cognitive arousal is defined as uncontrollable invasive cognition (Satpute et al., 2019). Therefore, rumination—as a form of invasive cognition—causes selective attention concerned with perceived negative cues before going to bed, which then stimulates more cognitive arousal and further delays the onset of sleep (Espie, 2007). Accordingly, previous studies have confirmed that rumination can cause insomnia (Amaral et al., 2018). Other studies suggested that rumination may be a mediating mechanism between stressful events and insomnia (Amaral et al., 2018; Slavish and Graham-Engelnd, 2015). Further research indicated that there was a significant positive correlation between fatigue and rumination and that fatigue may indirectly affect depression through rumination (Zhang et al., 2019). However, few studies are concerned with the sleep quality of renal transplant patients in China, and it is unclear whether rumination plays a mediating role between fatigue and sleep quality among these patients. Thus, this study aims to explore the association between fatigue and sleep quality and to investigate the mediating effect of rumination.

METHODS
The Cronbach’s alpha ranged from 0.772 to 0.850; higher scores indicate higher rumination levels. Multidimensional Fatigue Inventory (MFI-20) was used to evaluate patients’ fatigue in our study.

**Results**

**Sample Characteristics**

This study was conducted with 192 renal transplant patients who were reexamined at outpatient departments in three first-class hospitals in Jinan, Shandong Province, China. Table 1 displays the patients’ demographic characteristics and a distribution of their sleep quality. The patients’ average age was 44 years (SD, 10.65; range, 20–75 years). The majority of the sample participants were male (69.3%), married (91.7%), and reached middle school (38.5%). Only 43.2% of the participants’ income was between 2000 and 4000 CNY/month. Furthermore, most patients had received their kidney transplants more than 5 years ago, and 70.3% of them exhibited normal creatinine levels. In addition, statistically significant differences in sleep quality were found among sex (r = -0.394, p < 0.001), age (F = 3.392, p = 0.036), and duration of dialysis before transplantation (F = 3.442, p = 0.034), respectively. The Pearson product-moment correlations indicated that sleep quality was positively correlated with both fatigue (r = 0.394, p < 0.001) and rumination (r = 0.418, p < 0.01). Moreover, fatigue was also positively correlated with rumination (r = 0.368, p < 0.001).

**Correlational Analyses**

Table 2 displays the means, SDs, and correlations of the main study variables. The means and SDs pertaining to the total scores of fatigue, rumination, and sleep quality were 46.49 (11.37), 37.49 (10.11), and 5.40 (2.69), respectively. The Pearson product-moment correlations revealed that sleep quality was positively correlated with both fatigue (r = 0.394, p < 0.001) and rumination (r = 0.418, p < 0.01). Moreover, fatigue was also positively correlated with rumination (r = 0.368, p < 0.001).

**Mediating Effect Test**

The results of the mediation analysis are displayed in Table 3. The data were standardized before the analysis of the mediating effect was conducted. After controlling for demographic variables, the results revealed that the total effect (path c) of fatigue on sleep quality was 0.37 (p < 0.001); fatigue was significantly associated with rumination (β = 0.35, p < 0.001) and rumination was significantly associated with sleep quality (β = 0.29, p < 0.001). Furthermore, even when rumination was controlled, the previously significant relationship between fatigue and sleep quality (direct effect) still existed (β = 0.27, p < 0.001). In addition, the bootstrap test results indicate that the 95% CI of rumination’s indirect effect between fatigue and sleep quality did not include zero (95% CI, 0.154–0.419; indirect effect, 0.10). It also revealed that the mediating effect was statistically significant, which indicates that rumination acts as a partial mediator between fatigue and sleep quality. The standardized mediating effect was 0.10, and the mediating effect accounted for 27% of the total effect. Figure 1 displays the final mediating model.
which leads to a decline in sleep quality. This study discovered a lower incidence of sleep disorders, only 19.3% (defined as a PSQI score >7) in kidney transplant recipients than in the studies by Xie et al. (2018) (29.2%, poor sleeper defined as PSQI >7) and Reilly-Spong et al. (2013) (41%, poor sleeper defined as PSQI >8). Several factors may account for this difference; these include the following: these patients’ transplants occurred more than 1 year ago, their renal functions have had time to recover, their sleep difficulties might be relieved, the sample size may be too small, the sample populations differ, and the data were collected from different cultural settings. Nevertheless, this finding indicates that although the patients’ sleep difficulties have been alleviated to some extent after their kidney transplants, the overall poor sleep quality persists. Hasanzamani et al. (2020) also demonstrated that renal transplants can improve patients’ sleep conditions after 6 months (Hasanzamani et al., 2020). Generally speaking, patients still have sleeping disorders more than a year after their kidney transplants, and the prevalence is high.

Furthermore, the study findings suggested that there was a significant positive correlation between fatigue scores and sleep disorder scores. This implies that higher fatigue scores lead to higher sleep quality and vice versa. The table below shows the bivariate correlation among fatigue, rumination, and sleep quality.

### TABLE 2. Bivariate Correlation Among Fatigue, Rumination, and Sleep Quality

| Variable | 1 | 2 | 3 | Mean (SD) |
|----------|---|---|---|-----------|
| Fatigue  | 1 | 0.368*** | 0.394*** | 46.49 (11.37) |
| Rumination | 0.368*** | 1 | 0.418*** | 37.49 (10.11) |
| Sleep quality | 0.394*** | 0.418*** | 1 | 5.40 (2.69) |

***p < 0.001.
disorder scores and poor sleep quality, which is in line with previous findings (Rodrigue et al., 2011). Studies also discovered that fatigue, hypertension, and hair loss are the three most common symptoms among renal transplant recipients in China (Du et al., 2021). In addition, because the patients cannot engage in heavy physical activities due to their transplanted kidneys, they become more sedentary and less active, which leads to fatigue. However, this type of fatigue is different from the fatigue caused by normal activities because it causes apathy and discomfort in patients' limbs, which makes it difficult to fall asleep. However, fatigue not only affects quality of life but also reduces patients' tolerance to immunosuppressants, which increases their incidence of immune rejection and risk of death (Hucker et al., 2017). In addition, previous studies have pointed out that the severity of fatigue is closely related to sleeping disorders, and poor sleep quality will aggravate the fatigue of patients, which eventually lead to a decline in the quality of life (Tandukar et al., 2019).

The study results further indicate that, in addition to directly affecting patients sleep quality, fatigue also indirectly affects sleep quality through rumination. The research confirmed that fatigue is positively correlated with rumination, whereas rumination is positively correlated with sleeping disorders. Very few studies have explored the relationship between fatigue and rumination, and only explored the effects of work-related fatigue in employees (Kompier et al., 2012; Querstret and Cropley, 2012; Querstret et al., 2017). Nevertheless, previous studies revealed several correlations: physical fatigue can lead to a decline in athletic ability (i.e., lack of muscle strength); cognitive fatigue can lead to a decline in cognitive ability (i.e., poor attention and sensitivity); and mental fatigue can lead to negative emotions or stress disorders (Abd-Elfattah et al., 2015; Rudroff et al., 2016). Thus, fatigue is a complex concept, and different performance of fatigue can enhance patients' ruminant thinking levels, resulting in reduced sleep quality. Li et al. (2019) found that stressful life events can both directly and indirectly affect sleep quality through rumination (Li et al., 2019). Furthermore, because stress can lead to the activation of the locus coeruleus noradrenaline system and the hypothalamus pituitary adrenal axis, it can increase excitability and aggravate existing difficulties in falling asleep (Richardson, 2007; Sladek et al., 2020). According to Morin et al. (2003), insomnia-hyperactivity theory, cognitive arousal may play an important role in sleep disorders (Morin et al., 2003). Therefore, higher levels of rumination make people more prone to experiencing negative reevaluations of the past, which increases their cognitive arousal and reduces sleep quality, thus supporting the “emotional flow” theory (Nabi, 2015).

Diagnoses of renal failure and the subsequent kidney transplants are major life events that place strain on patients. Furthermore, because most patients will experience fear and then try to control their fear situation (anger), they may experience a “fight response,” which will affect their sleep. In addition, this result also supports the stress theory (Lazarus and Folkman, 1984). Stress theory refers to the process of individual psychological adjustment and adaptation when faced with stress, whereas coping styles pertain to behavioral patterns that buffer and control an individual's response to stress stimuli during the coping process; this is aimed at solving or mediating an individual's emotions (Folkman et al., 1986; Lazarus and Folkman, 1984). Positive coping styles directly affect an individual's compliance with disease treatment, which then affect their overall health status; negative coping styles are not conducive to patients' health outcomes (Lazarus and Folkman, 1984; Lee et al., 2013). Rumination is a type of negative coping style

### TABLE 3. Mediation of Rumination Between Fatigue and Sleep Quality

|                      | R²  | F   | Coefficient | SE  | t   | p    | LLCI | ULCI |
|----------------------|-----|-----|-------------|-----|-----|------|------|------|
| Outcome: rumination  | 0.164 | 9.177 | 0.35        | 0.067 | 5.198 | <0.001 | 0.218 | 0.485 |
| Fatigue             |     |     |             |      |      |      |      |      |
| Outcome: sleep quality | 0.299 | 15.853 | 0.27        | 0.066 | 3.998 | <0.001 | 0.134 | 0.396 |
| Fatigue             |     |     |             |      |      |      |      |      |
| Rumination           |     |     |             |      |      |      |      |      |

*a* Path fatigue—rumination.

*b* Path fatigue—sleep quality when rumination acting as a mediator (indirect effect).

*c* Path rumination—sleep quality.

**LLC1**, lower level of confidence interval; **ULC1**, upper level of confidence interval.

![FIGURE 1. The mediation model of rumination between fatigue and sleep quality (**p < 0.001**).](chart.png)
that exacerbates the severe decline of sleep quality. When engaging in ruminant thinking, individuals easily become caught up in memories of negative events; this leads to excessive fantasizing during which they lose track of time (Abd-Elfattah et al., 2017). Self-accusatory thoughts are common while ruminating and are focused on the individual’s past mistakes and subsequent consequences. Individual’s then question why their problems are unique to themselves, which further aggravates their negative thoughts and behaviors. Therefore, the cycle of rumination is characterized by a focus on negative emotions, which then increases insomnia-inducing factors, maintenance factors of insomnia, and finally persistent symptoms of insomnia (Sladek et al., 2020).

This study demonstrated that rumination acts as a mediator between kidney transplant recipients’ fatigue and their sleep quality. However, given that the causes of fatigue are related to the source of transplanted kidney (de Groot et al., 2013), graft dysfunctions (Rodrigue et al., 2011), and the use of immunosuppressants (Chan et al., 2013), reducing fatigue in patients may not be easy. Therefore, medical staff should use effective measures that reduce patients’ levels of rumination. Furthermore, rumination causes individuals to fixate on the negative aspects of events and the possible negative effects; this induces negative emotional experiences (e.g., loneliness and depression) that cause adverse health consequences, such as impaired sleep quality (Sekercioglu et al., 2015; Zhang et al., 2017). Accordingly, nurses should pay close attention to the emotional states and psychological characteristics of their patients. This includes practically caring about patients during daily nursing work, such as encouraging their families to visit, to correct patients’ flawed perspectives over time. Meanwhile, the tendency of ruminating individuals to indulg in their own negative thought patterns and emotions increases their need for more social support to alleviate their inner pain. Therefore, nurses should provide the necessary social support for kidney transplant patients, such as strengthening communication with them and holding relevant informative lectures. In addition, rumination interventions are very important. Previous studies have revealed that mindfulness therapy (Dutch, 2018; Fresnics et al., 2019), cognitive behavior interventions (Spinhowen et al., 2018), and working memory training (Hirsch et al., 2020; Hoorbelke and Koster, 2017) all play important roles in eliminating negative thinking and promoting positive thinking.

Limitations
First, the study limitations relate to the use of a convenience sample of kidney transplant recipients located in one geographic area. This means that the representativeness and extrapolation efficiency of the conclusions are limited. Second, this study used a cross-sectional design to explore the effects of rumination on the relationship between fatigue and sleep quality of renal transplant patients. Consequently, this design cannot provide an accurate explanation for the causality between the two variables. Therefore, longitudinal studies or randomized controlled trials are necessary to confirm our results. Third, rumination was the only mediator considered in this study to determine the relationship between fatigue and sleep quality. However, other mediators may also affect the relationship between fatigue and sleep quality, including social support, family functions, anxiety, and depression. Future studies should include additional variables to comprehensively assess the impact of the results. Finally, the patients’ conditions were assessed with a self-reported questionnaire, which may be biased.

CONCLUSIONS
In summary, our study found a high incidence of sleep disorders and demonstrated that rumination in renal transplant patients function as a partial mediator between the dimensions of fatigue and sleep quality. According to our findings, fatigue-related intervention strategies achieved marginal success, but rumination-related interventions might lead to the greatest direct contribution toward preventing fatigue-related sleep difficulties.

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