

Research article

The influence of stress on mental health among Chinese college students: The moderating role of psychological suzhi

Huixin Wang^{a,1}, Ruxue Jia^{b,1}, Min Zhang^a, Wenyi Fan^{a,*}

^a Department of Applied Psychology, Binzhou Medical University, Yantai, China

^b Psychological Center, Xinghua Fourth People's Hospital, Taizhou, China

ARTICLE INFO

Keywords:

Chronic stress

Acute stress

Psychological suzhi

Mental health

College students

ABSTRACT

Depending on its duration, stress can be divided into chronic and acute stress, both of which can be detrimental to an individual's mental health. Psychological suzhi may act as a protective factor that buffers the adverse effects of stress. This study aimed to explore the moderating role of psychological suzhi in the relationship between these two types of stress and mental health based on a dual-factor model of mental health. Study 1 explored the moderating role of psychological suzhi on the relationship between chronic stress and mental health using the Adolescent Self-Rating Life Events Check List, College Student Psychological Suzhi Scale Brief Mental Health Version, Satisfaction With Life Scale, and 12-item General Health Questionnaire to investigate 919 Chinese college students. A hierarchical regression model was used to examine the moderating effects. Study 2 examined the moderating role of psychological suzhi on the relationship between acute stress and mental health. Participants ($N = 56$) were classified into high ($N = 30$) and low ($N = 26$) psychological suzhi groups based on the Psychological Suzhi Scale. They completed the Trier Social Stress Test for Groups and a specific control condition, and their state anxiety and happiness levels were assessed. Data were analyzed using a mixed-design repeated-measures ANOVA. The results of Study 1 revealed that psychological suzhi moderated the influence of chronic stress on the negative indicator of mental health (psychological symptoms) ($\beta = -0.18$, $t = -6.90$, $p < 0.001$). The results of Study 2 showed that psychological suzhi moderated the effect of acute stress on the negative indicator of mental health (state anxiety) [$F(1, 54) = 4.79$, $p < 0.05$, $\eta^2 = 0.08$]. Psychological suzhi can moderate the influence of both chronic and acute stress on the negative indicators of college students' mental health but cannot moderate the influence on the positive indicators of mental health.

1. Introduction

The World Health Organization defines mental health as a state of positive psychological well-being that goes beyond a disease-free state. Mental health is an important public health and social problem affecting the development of modern society. A survey on the mental health problems of Chinese college students revealed that the prevalence rates of depression, anxiety, and stress were 42.5%, 60.2%, and 33.5%, respectively, indicating that mental health has become an issue that cannot be ignored [1].

* Corresponding author.

E-mail address: fanwenyi163@163.com (W. Fan).

¹ These authors contributed equally to this paper.

Among the many factors that affect mental health, stress has received considerable attention from researchers. The university stage is a period when individuals undergo role changes and social adaptation, and college students not only face academic pressures, but also interpersonal, employment, economic, and family pressures. Therefore, college students have become a high-risk group for stress. Studies have demonstrated that chronic stress can cause a series of psychological problems, with the cumulative effect of stressors serving as a significant predictor of symptoms associated with depression and anxiety [2–4]. Prolonged exposure to stress induces neuronal atrophy, which is characterized by synaptic loss and diminished volume in the hippocampus and prefrontal cortices, potentially leading to mood disorders, cognitive impairments, and behavioral alterations [5]. In addition to chronic stress accumulated over an extended duration, college students also encounter various acute stressful events, such as examinations or emergencies. Acute stress also affects mental health. Studies have shown that acute stress is significantly positively correlated with negative emotions and state anxiety [6].

Although stress is an important factor affecting individual development, not all individuals experiencing stress have impaired mental health. The impact of stress on an individual depends not only on the magnitude and duration of the stress but also on the individual's assessment of the stressful situation and personality characteristics. Hobfoll proposed that positive psychological traits enable individuals to develop enduring internal resources to cope better with stressful events [7].

Psychological suzhi is an academic concept with local characteristics proposed against the background of China's essential-qualities-oriented schooling (Suzhi education). It refers to a type of psychological quality based on physiological conditions and is closely related to an individual's adaptive and creative behavior. Its basic characteristics include stability, essence, and implicitness [8]. With the implementation of suzhi education, the cultivation of psychological suzhi has become an important goal and task of contemporary school education. The relevant policy states that "mental health education and guidance should be provided to students of different ages in various ways to help students improve their psychological suzhi, improve their personality, and enhance their ability to withstand setbacks and adapt to the environment." Psychological suzhi is closely related to mental health. Empirical studies have shown that under the same competition and pressure, adolescents with high psychological suzhi exhibit better emotional regulation [9] and are less likely to suffer from anxiety, depression, and academic fatigue [10,11]. Wu et al. showed that psychological suzhi could buffer the negative effects of bullying on social anxiety [12]. Therefore, we speculate that good psychological suzhi can play a protective role in the process of stress, mitigating the negative impact of stress on mental health.

Existing research has predominantly focused on the negative aspects of mental health, such as depression and anxiety, while ignoring the positive aspects of mental health. With the development of positive psychology, mental health is no longer solely defined by the absence of mental illness but rather encompasses a comprehensive evaluation based on both positive and negative indicators [13]. Accordingly, researchers have proposed a dual-factor model of mental health (DFM) for the first time, considering mental health as the unity between subjective well-being and psychopathological symptoms [14]. Therefore, building on the DFM, this study explored the moderating effect of psychological suzhi under chronic and acute stress, which is of great significance in promoting the mental health of college students and advancing research on the mechanism of psychological suzhi. The hypothesized research model is shown in Fig. 1.

2. Literature review

2.1. Theoretical basis: dual-factor model of mental health (DFM)

Medical models have dominated the mental and physical health research for nearly 100 years. In the medical field, a state of mental health is considered when a person does not exhibit a range of physical and psychological symptoms of mental illness. Through the efforts of scholars in the field, the Diagnostic and Statistical Manual of Mental Disorders (DSM), which is a relatively complete set of diagnostic and identification criteria for somatic and mental illnesses, has been developed and refined and is widely used worldwide to evaluate the mental health status of individuals. However, with improvements in productivity and living conditions, people have also gained a new understanding of mental health. Researchers have recognized the limitations of traditional medicine models in mental health assessment. Positive psychology has created new trends in the field of study. It is believed that the assessment of human mental health should encompass not only negative psychopathology diagnoses but also positive standards, such as those related to happiness.

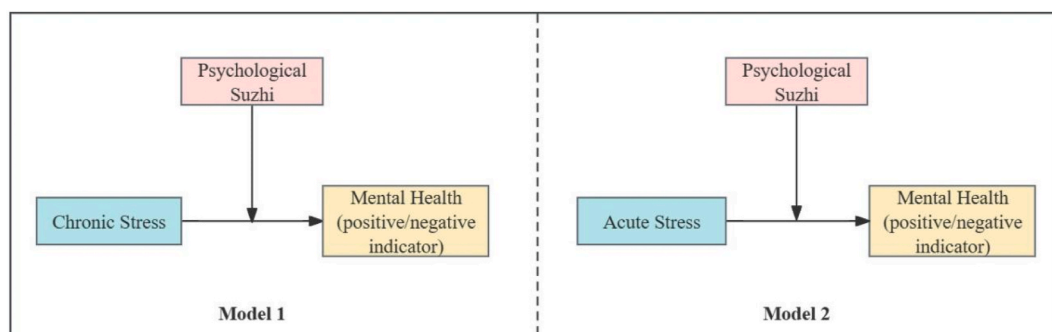


Fig. 1. Schematic diagram of the research model.

Greenspoon and Saklofske officially proposed DFM in 2001 [15]. The model incorporates positive mental health indicators based on traditional mental health assessment methods, and considers mental health as the unity of subjective well-being and psychopathological symptoms [14]. The positive and negative mental health indicators are both independent and interrelated.

Several empirical studies have validated this model. Antaramian selected college students as participants and tested the application of the DFM in psychological regulation and education [14]. During the research process, it was found that asymptomatic status and high happiness could significantly predict psychological regulation and promote academic success. Dong et al. selected high school students as research subjects and used the Chinese Middle School Student Mental Health Scale as a negative indicator during the research process, while the Life Satisfaction Scale and the Positive and Negative Emotional Scale were used as positive indicators to explore the applicability of the DFM to Chinese high school students [16]. They also compared a single-factor model with a new psychological health assessment method to evaluate the degree of fit of the DFM. The research concluded that the fitting indicators of the DFM were better than those of the single-factor model, further indicating that both positive and negative indicators can effectively assess an individual's overall mental health status.

Compared with traditional mental health assessment models, the DFM has the following advantages. First, using both positive and negative measurement standards can more comprehensively explain, reflect, and differentiate an individual's mental health situation [17]. Second, based on the traditional mental health assessment model, it distinguishes between symptomatic but self-satisfied and susceptible individuals, thereby enhancing the pertinence and effectiveness of psychological interventions [18]. Third, it provides a new way of intervening in mental health, which not only reduces psychological symptoms but also improves subjective well-being [17]. Fourth, it provides operability to achieve complete mental health. In the new mental health assessment model, the subjective well-being and psychopathology indices measure the positive and negative dimensions of mental health, respectively, which constitute the DFM. The subjective well-being of individuals is composed of three factors: life satisfaction, positive emotions, and negative emotions. Psychopathological indicators include internalizing and externalizing problems. These two indicators are considered artificially synthesized composite indicators. However, there are some problems with the DFM of composite indicators. First, there is overlap in specific indicators. Second, the composite indicator is not sufficiently sensitive. Third, emotional indicators are prone to fluctuation and instability [18]. Fourth, the operability of the composite indicators in psychological interventions is weak. Therefore, researchers are exploring the application effects of the DFM using a single indicator. The single-indicator DFM employs only one indicator to measure the negative dimension of mental health and only one indicator to measure the positive dimension. After empirical testing, the single-indicator DFM was found to be suitable for describing an individual's mental health status [17,19].

Previous studies have shown that the 12-item General Health Questionnaire (GHQ-12) has a screening sensitivity of 98.3% in an epidemiological survey of various mental diseases in individuals over 18 years of age, and its sensitivity to 12 common mental diseases is above 93%, making it suitable for measuring mental disorders [20]. Therefore, in Study 1, positive mental health was measured using the Life Satisfaction Scale, and negative mental health was measured using the GHQ-12. In the experimental study, because life satisfaction has long-term stability and psychological symptoms is persistent, they are not suitable as indicators reflecting immediate changes in the experiment. Happiness implies that individuals feel more positive than negative emotions, and happiness has a good fit as a positive indicator of mental health [21]. State anxiety is the most common emotional response in acute stress situations [22]. Therefore, in Study 2, happiness and state anxiety were selected as immediate indicators of mental health to reflect an individual's mental health status under acute stress.

2.2. Hypotheses development

2.2.1. Stress

The concept of stress, first proposed by Selye, refers to a non-specific systematic response of the body to stimulation by internal and external environmental factors [23]. Stress can be classified as acute or chronic, based on its intensity and duration. Chronic stress is defined as a low threat lasting for a month or longer that causes pain and disturbances [24]. Chronic stress is typically assessed using questionnaires. Acute stress has a short duration and high intensity [25]. The most classic paradigm is the Trier Social Stress Test (TSST). Uncontrollability of and threats to social evaluation are important situational factors that induce individual social psychological stress. The TSST includes manipulation of both, which can effectively activate the hypothalamic–pituitary–adrenal axis (HPA) and significantly enhance the subjective stress experience of participants [26]. The TSST-G is a group version of the stress-induced paradigm that can be tested on multiple participants simultaneously.

Since 1970, the bio-psychosocial model has been favored by many scholars in the academic community, and the issue of how psychological stress affects human health has gradually become a focus of research. Stress is a complex process within the body that includes not only physiological, but also psychological and behavioral responses. Various stimuli in the external environment can affect humans. When confronted with a stressor, individuals assess it based on their own experiences, perceptions, and other factors. The results of this assessment will influence the individual's subsequent response [27]. On the one hand, stress can cause the rapid secretion of adrenocorticotrophic hormone (ATH) in the face of danger, triggering a “fight or flight” response. This physiological response aids individuals in enhancing their “fighting strength” to cope with emergencies, thereby leading to increased environmental adaptability and survivability [28]. On the other hand, stress can also damage individuals' physical and mental health, with excessive stress leading to a variety of physical diseases and mental disorders [29].

2.2.2. Psychological suzhi

Psychological suzhi is a concept proposed by Chinese scholars and is akin to personality. It represents a psychological quality that internalizes external stimuli as implicit, stable, and basic, with basic, derivative, and developmental functions based on physiological

conditions. It is closely related to people's adaptive and creative behaviors [30]. Psychological suzhi consists of three dimensions: cognition, personality, and adaptability. The cognitive factor refers to the cognitive characteristic of the individual toward objective things and is the most basic component. The personality factor refers to the personality characteristic that an individual displays in the activity and has an adjustment function. This is the core component. Adaptability refers to the ability of an individual to adapt to their environment [8]. The relationship between psychological suzhi and personality is mainly embodied in the following aspects: First, personality is the internal tendency of individual behavior, while psychological suzhi is the unity of an individual's content and function in psychology and behavior. The aim of psychological suzhi research is to explore the inner basis of psychology and behavior and reveal the outer and adaptive psychological and behavioral functions. Second, personality is shown as individual differences in thought, emotion, and behavior, whereas psychological suzhi is shown as differences in internal stability, external adaptation, and health functions [31]. The person-context interaction theory posits that the impact of stress on individuals depends not only on the environment, but also on personality traits and the cognition of stressful events [32]. Previous studies have demonstrated that individuals with lower levels of psychological suzhi are more likely to encounter mental health issues than those with higher levels. Empirical studies of the relationship between psychological suzhi and mental health among children and adolescents have shown that psychological suzhi can significantly and negatively predict depression, social anxiety, and problem behaviors [31,33,34]. The relationship model between psychological suzhi and mental health emphasizes that psychological suzhi is an endogenous factor that determines the level of individual mental health. Furthermore, psychological suzhi can moderate the influence of external risk factors on individual mental health [35].

2.2.3. *The relationship between chronic stress and mental health*

Chronic stress is caused by stressful events that have a lower intensity of stimulation and pose a lower threat to individuals, such as long-term work pressure, learning pressure, life pressure, and chronic diseases. These events can cause pain and interfere with personal life. Later, researchers further standardized the definition of chronic stress, characterizing it as stress persisting for one month or longer [26]. The commonly used scales for measuring chronic stress are the Perceived Stress Scale, Stress Response Questionnaire, and Adolescent Self-Rating Life Events Check List. The Adolescent Self-Rating Life Events Check List is suitable for measuring major events and daily life trivialities while also considering the frequency and intensity of stressful events. In existing studies, this scale has been widely applied to adolescent populations, particularly middle school and college students [36,37]. Previous studies found that higher levels of chronic stress are associated with an increased risk of anxiety, depression, and other negative emotions [38,39]. Stressful life events were a significant risk factor for the development of depression. In addition, the higher the stress level, the lower the positive emotions and subjective well-being [40]. Therefore, the following hypotheses are proposed:

- H1.** Chronic stress positively predicts negative mental health indicators (psychological symptoms) among college students.
- H2.** Chronic stress negatively predicts positive mental health indicators (life satisfaction) among college students.

2.2.4. *The moderating role of psychological suzhi in the relationship between chronic stress and mental health*

Wu et al. studied the effect of psychological suzhi on negative life events (bullying) and social anxiety and found that psychological suzhi can buffer the negative impact of negative life events on social anxiety [41]. Wu examined the effects of chronic stress on anxiety, depression, and negative emotions in middle-school students and found that psychological suzhi can play a direct and stabilizing protective role in stressful situations [22]. In addition, relevant studies have provided empirical evidence for the moderating effect of psychological suzhi [22]. For example, psychological resilience refers to an individual's ability to persevere in difficult circumstances and is an important embodiment of psychological suzhi [8]. Studies have shown that improving psychological resilience can reduce the negative effects of chronic stress [42]. Existing research indicates that psychological suzhi can buffer the effects of chronic stress on negative mental health indicators. However, the relationship between chronic stress and positive mental health indicators remains unclear. Therefore, this study adopted the DFM of mental health to explore the moderating role of psychological suzhi in the effects of chronic stress on positive and negative mental health indicators. Thus, we propose the following hypotheses:

- H3.** Psychological suzhi moderates the association between chronic stress and the negative mental health indicator (psychological symptoms).
- H4.** Psychological suzhi moderates the association between chronic stress and the positive mental health indicator (life satisfaction).

2.2.5. *The relationship between acute stress and mental health*

Acute stress can be caused by intense, novel, or unpredictable emergencies. Examples include examinations, interviews, physical stimulations, sudden traffic accidents, and sudden natural disasters. In laboratory studies, acute stress is induced by simulating short-term life events. Acute stress can induce a range of physiological and psychological responses. On the one hand, acute stress influences individual homeostasis [43], causing nervousness, anxiety, and other negative emotions. When the intensity of acute stress is too high, an individual cannot cope, and excessive negative emotions may be generated, which may have a negative effect on physical and mental health [44]. On the other hand, acute stress can also affect brain function [45]. Studies have shown that the amygdala is an important brain region for processing negative emotions [46]. However, when individuals are in a state of acute stress, researchers found that the response sensitivity of the amygdala is enhanced [47]. In addition, through EEG studies, researchers have found that the generation of unhappiness during social activities is correlated with EEG asymmetry in the right prefrontal lobe [48]. Under acute stress, the right prefrontal lobe is activated, resulting in sadness and other negative emotions [49]. Therefore, the following hypotheses are proposed:

H5. Acute stress positively predicts the negative mental health indicator (state anxiety).

H6. Acute stress negatively predicts the positive mental health indicator (happiness level).

2.2.6. *The moderating role of psychological suzhi in the relationship between acute stress and mental health*

The effects of acute stress on positive mental health indicators and the moderating role of psychological suzhi in this relationship remain unclear. To accurately understand the role of psychological suzhi in the relationship between acute stress and negative and positive mental health indicators, this study utilized the TSST paradigm to investigate the moderating effect of psychological suzhi on the effects of acute stress on positive and negative mental health indicators. Thus, we propose the following hypotheses:

H7. Psychological suzhi moderates the association between acute stress and the negative mental health indicator (state anxiety).

H8. Psychological suzhi moderates the association between acute stress and the positive mental health indicator (happiness level).

Study 1: The influence of chronic stress on mental health: the moderating role of psychological Suzhi.

3. Methods

3.1. *Participants*

We used a random cluster sampling method to survey 1081 college students from six cities in Shandong province. After excluding invalid questionnaires, we obtained 919 valid questionnaires, with a recovery validity rate of 85.01%. The questionnaire measured chronic stress, psychological suzhi, mental health, and demographic variables of the participants. The final sample consisted of 345 men (37.5%) and 574 women (62.5%) aged 16–26 years ($M = 19.70$, $SD = 1.48$). Among them, 310 (33.7%), 230 (25.0%), 194 (21.1%), and 185 (20.1%) were freshmen, sophomores, juniors, and seniors, respectively. The procedures and principles of this study were approved by the Ethics Committee of Binzhou Medical University, Shandong, China (Approval Number: 2022-201). All the participants provided written informed consent.

3.2. *Measures*

3.2.1. *Adolescent Self-Rating Life Events Check List*

Chronic stress was measured using the Adolescent Self-Rating Life Events Check List (ASLEC) compiled by Liu et al. It is suitable for evaluating the frequency and intensity of stressful life events in adolescents, especially middle-school and college students [50]. The scale has 27 items, including 6 common negative life events in interpersonal relationships, learning pressure, punishment, loss, health adaptation, and others. It has good reliability and validity. Participants were asked to report whether each event had happened in the last 12 months. If it had, the participants would be rated at 5 levels according to their psychological feelings at the time of the event, ranging from “no impact” to “extremely heavy impact”. The statistical indices of the scale include the frequency of occurrence of events and amount of stress, and the cumulative score of each event is the total amount of stress. In this study, the Cronbach’s alpha for the entire questionnaire was 0.93.

3.2.2. *College student Psychological Suzhi Scale brief mental health version*

The College Student Psychological Suzhi Scale Brief Mental Health Version was revised by Wang et al., in 2017 [51]. The scale is suitable for assessing the psychological suzhi of college students, and it adopts a 5-point scoring method. The scale contains 36 questions with three dimensions and 12 factors. The Cognitive Suzhi subscale consists of three factors: metacognition, purpose, and openness. The Personality Suzhi subscale comprises three factors: self-confidence, self-control, and optimism. The Adaptability subscale includes six factors: occupational adaptation, social adaptation, interpersonal adaptation, emotional adaptation, learning adaptation, and physiological adaptation. In this study, the Cronbach’s α coefficient of the scale was 0.87.

3.2.3. *Satisfaction with life scale*

The Satisfaction with life scale (SWLS) was compiled by Pavot and Diener in 1993 and revised by Yuen in 2002 [18]. The scale is suitable for assessing life satisfaction and consists of five questions and seven choices. Higher scores indicate higher life satisfaction. This scale is widely used in more than 150 countries and has good reliability and validity. In this study, the internal consistency of the scale was 0.82.

3.2.4. *12-Item general health questionnaire*

The 12-item General Health Questionnaire (GHQ-12) was compiled by Goldberg in 1978 and adapted by Zheng, based on Chinese cultural characteristics [18]. The scale consists of 12 items, with three dimensions: body, anxiety, and depression. The score for the first two options of the four options was 0 and that for the last two options was 1. The cut-off point was set at 4; participants with an overall score ≥ 4 were suspected of mental illness. In this study, the internal consistency of the scale was 0.83.

3.3. *Statistical analysis*

IBM SPSS (version 22.0) was used for data analysis. Based on the scale results, we calculated the mean, standard deviation, and

correlation coefficients of the main variables. A hierarchical regression model was used to investigate the moderating effect of psychological suzhi on the relationship between chronic stress and mental health. In case of significant interaction effects, a simple slope analysis was performed to examine the effects of chronic stress separately according to psychological suzhi.

4. Results

4.1. Descriptive statistics and correlation analysis

The means and standard deviations of the study variables are presented in Table 1. Table 1 presents the bivariate correlations among the study variables. Chronic stress had a significant positive correlation with the negative indicator of mental health (psychological symptoms) ($r = 0.49, p < 0.001$), which indicates that the higher the level of chronic stress, the more psychological symptoms college students experienced. This result validated H1. Chronic stress had a significant negative correlation with the positive indicator of mental health (life satisfaction) ($r = -0.31, p < 0.001$), indicating that the higher the level of chronic stress, the lower the life satisfaction of college students. This result validated H2. There was a significant positive correlation between psychological suzhi and life satisfaction ($r = 0.57, p < 0.001$), indicating that college students with higher psychological suzhi had higher life satisfaction. We also found a significant negative correlation between psychological suzhi and psychological symptoms ($r = -0.54, p < 0.001$), indicating that college students with low psychological suzhi may have more psychological symptoms. Psychological suzhi was negatively correlated with chronic stress ($r = -0.40, p < 0.001$).

4.2. The moderation of psychological suzhi in the association between chronic stress and psychological symptoms

A hierarchical regression model was used to test the relationship between chronic stress and psychological symptoms as well as the moderating effect of psychological suzhi. Before conducting model testing, the independent variable (chronic stress) and moderating variable (psychological suzhi) were centralized. Gender and grade were placed as control variables in Model 1, chronic stress and psychological suzhi in Model 2, and the interaction between chronic stress and psychological suzhi in Model 3.

The results of the complete model are listed in Table 2. The results showed that chronic stress had a significant effect on psychological symptoms after controlling for gender and grade ($\beta = 0.32, t = 11.34, p < 0.001$), suggesting that the more chronic stress an individual faces, the more serious their psychological symptoms will be. The main influence of psychological suzhi on psychological symptoms was also significant ($\beta = -0.39, t = -13.81, p < 0.001$). The higher the psychological suzhi, the fewer the psychological symptoms. In addition, the interaction effect between chronic stress and psychological suzhi was also significant ($\beta = -0.18, t = -6.90, p < 0.001$). A simple slope analysis showed that chronic stress had a significant positive predictive effect on psychological symptoms in the high psychological suzhi group ($\beta = 0.02, t = 2.13, p < 0.05$). In the low psychological suzhi group, chronic stress predicted psychological symptoms more significantly ($\beta = 0.07, t = 13.47, p < 0.001$). This indicates that with the enhancement of chronic stress, individuals with low psychological suzhi are more likely to have psychological symptoms than individuals with high psychological suzhi (see Fig. 2). This result validated H3.

4.3. The moderation of psychological suzhi in the association between chronic stress and life satisfaction

A hierarchical regression model was used to test the relationship between chronic stress and life satisfaction, and the moderating effect of psychological suzhi. The results of the complete model are presented in Table 3. The results show that chronic stress had a significant impact on life satisfaction after controlling for gender and grade ($\beta = -0.10, t = -3.24, p < 0.01$), indicating that the more chronic stress individuals face, the lower their life satisfaction. The main influence of psychological suzhi on life satisfaction was also significant ($\beta = 0.54, t = 18.19, p < 0.001$). The higher the psychological suzhi, the higher the life satisfaction. In addition, the interaction between chronic stress and psychological suzhi was not significant ($\beta = -0.04, t = -1.48, p = 0.14$). This result indicated that H4 was not supported.

5. Discussion

This study systematically explored the effects of chronic stress on negative and positive indicators of college students' mental health. The results showed that chronic stress had a significant positive predictive effect on the negative indicator of mental health (psychological symptoms) and a significant negative predictive effect on the positive indicator of mental health (life satisfaction),

Table 1
Descriptive statistics and correlations among variables.

Variables	$M \pm SD$	Chronic stress	Psychological suzhi	Psychological symptoms	Life satisfaction
Chronic stress	44.50 $\pm$ 16.04	1			
Psychological suzhi	125.36 $\pm$ 17.71	-0.40***	1		
Psychological symptoms	2.11 $\pm$ 2.60	0.49***	-0.54***	1	
Life satisfaction	21.73 $\pm$ 6.62	-0.31***	0.57***	-0.43***	1

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

Table 2
Moderating analysis of psychological suzhi on the relationship between chronic stress and psychological symptoms.

Variables	Step 1		Step 2		Step 3	
	β	t	β	t	β	t
Gender	−0.12	−3.74***	−0.03	−1.10	−0.01	−0.52
Grade	0.19	5.98***	0.10	3.79***	0.09	3.56***
A: Chronic stress			0.32	11.34***	0.28	9.66***
B: Psychological suzhi			−0.39	−13.81***	−0.42	−14.99***
A x B					−0.18	−6.90***
R^2	0.06		0.40		0.43	
Adjusted R^2	0.06		0.39		0.42	
ΔR^2	0.06		0.34		0.03	
F	27.84***		150.44***		135.99***	

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

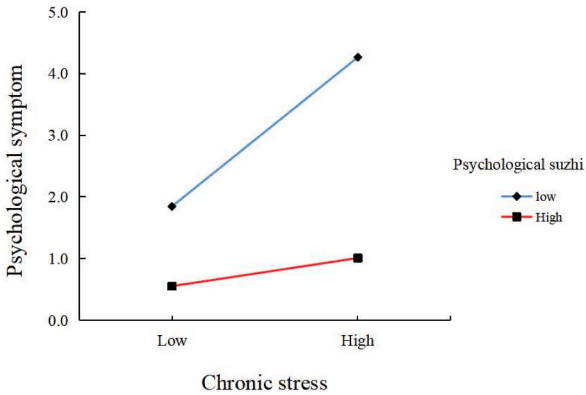


Fig. 2. Interaction between chronic stress and psychological suzhi on psychological symptoms.

Table 3
Moderating analysis of psychological suzhi on the relationship between chronic stress and life satisfaction.

Variables	Step 1		Step 2		Step 3	
	β	t	β	t	β	t
Gender	0.08	2.29*	0.01	0.17	0.01	0.29
Grade	−0.05	−1.62	0.05	1.76	0.05	1.69
A: Chronic stress			−0.10	−3.24**	−0.11	−3.50***
B: Psychological suzhi			0.54	18.19***	0.54	17.81***
A x B					−0.04	−1.48
R^2	0.01		0.34		0.34	
Adjusted R^2	0.01		0.34		0.34	
ΔR^2	0.01		0.33		0.00	
F	4.43*		116.51***		93.77***	

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

which is consistent with the results of previous studies [52]. The more stress college students are under, the more likely they are to develop negative emotions such as anxiety and depression, and the lower their life satisfaction. Chronic stress has a continuous effect on the individual, and as stressful events increase or become severe, the individual's mental energy is gradually depleted and mental health is impaired [2,53].

This study also found that college students' psychological suzhi negatively predicted their psychological symptoms and positively predicted their life satisfaction. According to the Adaptation Theory of Happiness, Diener et al. state that there are individual differences in adaptation, and that higher levels of happiness are produced when the body's internal emotional system is able to adapt well to external stimulus events [54]. In terms of the adaptability dimension of psychological suzhi, the better an individual's adaptability, the less negative impact stimulus events have on them, and the fewer psychological symptoms such as depression and anxiety.

The study further examined whether psychological suzhi could moderate the relationship between chronic stress and mental health. This study found that psychological suzhi moderated the relationship between chronic stress and the negative mental health indicator (psychological symptoms). Compared with individuals with high psychological suzhi, those with low psychological suzhi

exhibited a more pronounced upward trend in psychological symptoms as chronic stress increased. Individuals with higher personality suzhi are more likely to show better frustration resistance and adjustment abilities under stress. This result validates the model of the acting mechanisms of psychological suzhi proposed by Wang et al. [35]. This model suggests that psychological suzhi can moderate the impact of external pathogenic risk factors on an individual's mental health level. From the perspective of the diathesis-stress model, the various psychological problems of an individual are caused by the interaction of environmental factors and personal traits [55]. This model is generally used to explain the mechanism of psychological disorders such as anxiety and depression. Diathesis include a variety of physiological (genetically related physiological and biochemical levels) and psychological (cognitive, personality, and other psychological traits) factors of an individual [56,57]. Good psychological suzhi, as an intrinsically stable individual trait, can mitigate the negative effects of risk exposure on mental health. In addition, the results supported the stress-buffering hypothesis. This hypothesis suggests that positive qualities can play a protective role in the process of stress affecting individuals by reducing the negative effects of stress, individuals with positive qualities can adapt well in both low and high stress environments [58].

This study found that psychological suzhi had no significant moderating effect on the effect of chronic stress on the positive mental health indicator (life satisfaction). Individuals with high psychological suzhi scores had higher life satisfaction when their level of chronic stress was low. However, as the intensity of chronic stress borne by individuals increased, the life satisfaction of both groups decreased. This suggests that psychological suzhi has a relatively limited protective effect on college students' life satisfaction in situations of chronic stress. This provides some support for the stress-vulnerability hypothesis, where positive qualities tend to lose their cushioning effect in high-pressure environments [59].

In summary, chronic stress can positively predict negative indicators of mental health (psychological symptoms) and negatively predict positive indicators of mental health (life satisfaction) in college students. There are differences in the role played by psychological suzhi in the process of chronic stress affecting negative and positive indicators of mental health. In addition, in daily life, college students face not only chronic stress that accumulates over time, but also sudden acute stress. At present, there are few studies on the moderating effect of psychological suzhi on individual mental health under acute stress. Therefore, as it is necessary to conduct further research on acute stress, Study 2 was conducted.

Study 2: The influence of acute stress on mental health: the moderating role of psychological Suzhi.

6. Methods

6.1. Study design

This experiment utilized a mixed experimental design of 2 (experimental conditions: TSST-G, control) $\times$ 2 (groups: high psychological suzhi, low psychological suzhi). The experimental condition was the within-subjects variable, and the group was the between-subjects variable.

6.2. Participants

Before the experiment, we used G*Power software to estimate the sample size. According to our experimental design, with a medium effect size (0.25), a type I error probability α level of 0.05, and a test power of 0.80, the required sample size is at least 34 people. A total of 805 college students from a university in Shandong Province, China, were evaluated using the Psychological Suzhi Scale, and their scores were ranked from highest to lowest. The top 27% were selected as the group with high psychological suzhi, and the bottom 27% were selected as the group with low psychological suzhi. We used state anxiety as a negative indicator of mental health, and to eliminate the interference of additional variables, we excluded participants whose trait anxiety scores were more than one standard deviation higher than the normal population ($M = 43.31$, $SD = 9.20$) [60]. Considering the possible problems in the experiment (such as participants dropping out or invalid data), we recruited 60 participants. Finally, the complete data of 56 participants were collected. There were 30 participants (15 males and 15 females) in the high psychological suzhi group and 26 participants (12 males and 14 females) in the low psychological suzhi group. None of the participants had any relevant experimental experience, and those in the same group were unfamiliar with each other.

All the participants volunteered to participate in the experiment and signed an informed consent form before the experiment began. The local ethics committee approved the experimental protocol. At the end of the experiment, all the participants received a financial reward (30 yuan).

6.3. Measures

6.3.1. College student Psychological Suzhi Scale brief mental health version

This is consistent with the scale in Study 1.

6.3.2. State-trait Anxiety Scale

The Spielberger State-trait Anxiety Scale comprises two subscales that measure individual state and trait anxiety, each with 20 items [22]. The scale is graded on a four-point scale from 1 to 4. The higher the score, the higher the anxiety level. Since Zheng et al. tested the reliability and validity of the Chinese version, this scale has been widely used in China. In this study, the internal consistency coefficient of the State Anxiety scale was 0.90, and that of the Trait Anxiety scale was 0.89.

6.3.3. Subjective reporting of stress levels

The participants were asked to provide a 10-grade score for the tension and subjective pressure they experienced at each time point in the experiment [61].

6.3.4. Happiness level

The participants were required to rate the happiness they felt during the experiment on 11 levels.

6.4. Procedure

Before the experiment, the participants were divided into high and low psychological suzhi groups. They were asked to complete experimental tasks in the stress and control conditions, with an interval of one week between the two conditions. To balance the order effect, half of the high psychological suzhi participants completed the stress task before the control task, and the other half completed the control task before the stress task. The same applied to those with low psychological suzhi scores. The experiment was conducted in groups, with six people in each group. The order of each group was determined by drawing lots. The participants were informed that they would not communicate with each other during the experiment and were taken to a lounge.

The experimental procedure consisted of a baseline period, the TSST-G or control task, and a rest period (see Fig. 3).

6.4.1. Baseline period

During the baseline period, participants sat still for 10 min. Subsequently, their baseline levels of state anxiety and feelings of happiness were measured and subjective stress levels were reported (point 1).

6.4.2. Stress task

In the stress condition, the TSST-G paradigm was used, which is a standardized group test that enables subjects to experience higher levels of socially evaluated threats and a sense of loss of control. The task consisted of three phases: a preparation phase (10 min), a public speaking phase (2 min per person, 12 min total), and a mental arithmetic task phase (8 min). In the preparation phase, the participants were told that the topic of the public presentation was a job interview. The instruction manual required participants to prepare a resume and a 2-min free-form speech to introduce themselves to gain the interviewer's approval for the job interview. Participants were informed that their speech would be recorded in its entirety and that expressions and gestures made during the speech would be used for further analysis. Participants knew in advance that the interviewer would ask questions at any time during the process but did not realize that a mental arithmetic task would follow. After the preparation phase, anxiety, happiness, and subjective stress were measured (point 2). For the public speaking task, the participants were taken to another room and sat side-by-side in front of an interviewer and two conspicuous video cameras. The experimental assistant remained there after a brief introduction to the experimental task. They were then asked to speak in randomized order. After the participants completed their 2-min speech, they were silent for 20s and asked standardized questions that had been prepared in advance. After completing the questionnaire, the participants reported their subjective stress levels (point 3). After all the participants completed the public speaking task, a mental arithmetic task was performed. The participants were required to subtract 16 consecutively from a given number and report the results

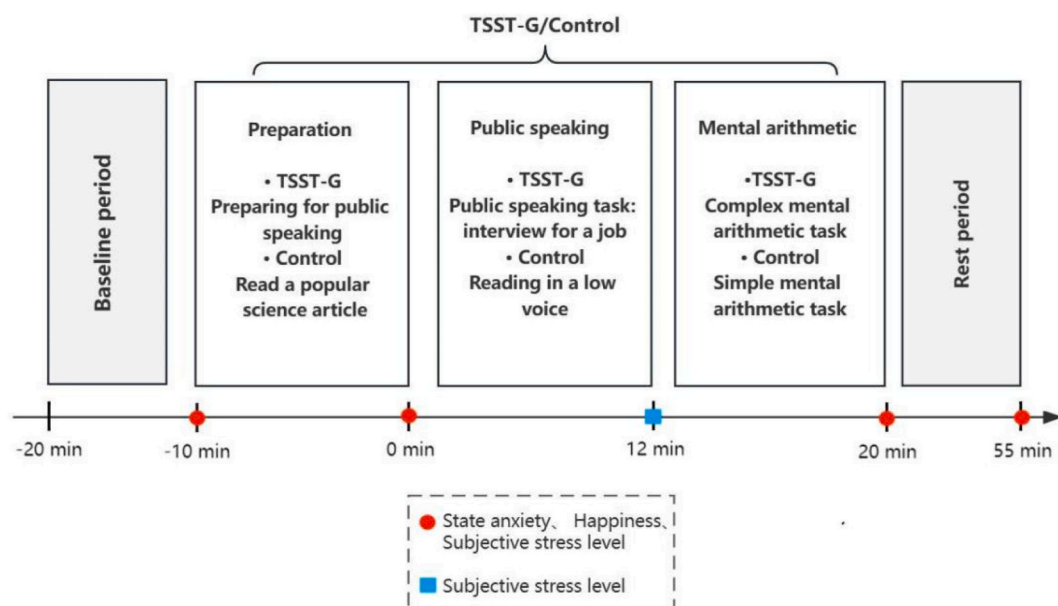


Fig. 3. Timeline of the TSST-G and control conditions.

quickly and accurately. When a participant made an error, the interviewer interrupted and told them to start from the beginning. At the end of the calculation, participants reported their state anxiety, happiness, and subjective stress levels (point 4). The interviewers were both men and women who wore white coats. Throughout the experiment, they were asked to remain expressionless and neutral and were not allowed to give any verbal or non-verbal feedback.

6.4.3. Control task

The only difference between the control and stress tasks was the absence of a stress-inducing component. The control task comprised three phases. In the speech-preparation phase, the researcher provided each participant with the same popular science article and asked them to read and briefly familiarize themselves with it (10 min). In the formal speech phase, participants were required to read popular science articles simultaneously in a low voice (12 min), and the interviewer did not assess each individual's reading performance. The mental math task was a simple addition task. The participants started with a simple number and then added five. During the presentation and mental arithmetic, there were no cameras, and the interviewers were still present; however, they did not wear white coats and did not comment on the participants.

6.4.4. Rest period

The rest period was 35 min. After this, participants reported their state anxiety, happiness, and subjective stress levels (point 5).

6.5. Statistical analysis

The data were analyzed using IBM SPSS (version 22.0). Stress, state anxiety, and happiness levels were analyzed using a mixed ANOVA. Psychological suzhi (Two groups: HPS, LPS) was specified as the between-subject factor, and experimental condition (Two conditions: TSST-G, control condition) and repeat measurement time point (Four time points: the baseline period, the preparation period, the speech and arithmetic tasks, and the rest period) served as the within-subject factors. Degrees of freedom were corrected using the Greenhouse–Geisser test when the sphericity assumption was not met. This resulted in 56 participants. Among them, 30 participants were in the HPS group and 26 were in the LPS group.

7. Results

7.1. Manipulation check

A 2 (experimental condition: TSST-G, control condition) x 5 (repeat measurement time point) repeated-measures ANOVA was conducted with subjective reporting of stress levels (tension, subjective pressure) as the dependent variable. The results indicated that the manipulation of acute stress was effective, and that subjectively reported stress levels were significantly higher in the stress condition than in the control condition. Specifically, the main effect of the time point was significant [$F_{\text{tension}}(4, 52) = 38.43, p < 0.001, \eta^2 = 0.75$; $F_{\text{pressure}}(4, 52) = 44.62, p < 0.001, \eta^2 = 0.77$]; the main effect of the experimental condition was significant [$F_{\text{tension}}(1, 55) = 45.35, p < 0.001, \eta^2 = 0.45$; $F_{\text{pressure}}(1, 55) = 45.03, p < 0.001, \eta^2 = 0.45$]; the interaction between time points and experimental condition was significant [$F_{\text{tension}}(4, 52) = 17.76, p < 0.001, \eta^2 = 0.58$; $F_{\text{pressure}}(4, 52) = 11.47, p < 0.001, \eta^2 = 0.47$]. In addition, there were no significant differences in the subjects' sense of tension and subjective pressure at baseline (point 1) between the TSST-G and control conditions [$t_{\text{tension}}(55) = 1.45, P = 0.15$; $t_{\text{pressure}}(55) = 0.31, P = 0.76$]. Additionally, in the TSST-G task stage, including the TSST-G preparation period (point 2) [$t_{\text{tension}}(55) = 7.94, p < 0.001$; $t_{\text{pressure}}(55) = 6.58, p < 0.001$], the end of speech (point 3) [$t_{\text{tension}}(55) = 6.37, p < 0.001$; $t_{\text{pressure}}(55) = 6.32, p < 0.001$], the end of arithmetic tasks (point 4) [$t_{\text{tension}}(55) = 3.71, p < 0.001$; $t_{\text{pressure}}(55) = 4.87, p < 0.001$], the subjects' sense of tension and pressure were significantly higher than the corresponding control condition. Further details are presented in Tables 4 and 5.

7.2. The moderation of psychological suzhi in the association between acute stress and state anxiety

Repeated measurement time points and experimental conditions were used as the within-subjects factors, with the psychological suzhi group used as the between-subjects factor. The results showed that the main effect of time point was significant [$F(3, 52) = 41.02, p < 0.001, \eta^2 = 0.70$]. The main effect of experimental condition was significant [$F(1, 54) = 28.37, p < 0.001, \eta^2 = 0.34$], and the state anxiety of the participants significantly increased under stress conditions. This result validated H5. The interaction effect of the time point and experimental conditions was significant [$F(3, 52) = 24.85, p < 0.001, \eta^2 = 0.32$]. Further details are presented in Table 6.

Table 4
Tension at different measurement time points.

Experimental condition	Point 1	Point 2	Point 3	Point 4	Point 5
TSST-G	1.61 ± 1.11	3.70 ± 1.87	3.82 ± 1.81	2.77 ± 1.99	0.95 ± 1.20
Control condition	1.34 ± 1.24	1.89 ± 1.45	2.11 ± 1.69	1.82 ± 1.63	0.75 ± 0.94
t	1.45	7.94	6.37	3.71	1.47
p	0.15	0.00	0.00	0.00	0.15

Table 5

Subjective pressure at different measurement time points.

Experimental condition	Point 1	Point 2	Point 3	Point 4	Point 5
TSST-G	1.73 ± 1.29	3.61 ± 1.92	3.63 ± 1.91	2.82 ± 2.04	1.04 ± 1.06
Control condition	1.66 ± 1.63	2.04 ± 1.46	2.09 ± 1.61	1.64 ± 1.48	0.77 ± 1.06
t	0.31	6.58	6.32	4.87	1.97
p	0.76	0.00	0.00	0.00	0.05

The group effect of psychological suzhi was significant [$F(1, 54) = 39.68, p < 0.001, \eta^2 = 0.42$]. Multiple comparisons showed that the level of state anxiety in the high psychological suzhi group was significantly lower than that in the low psychological suzhi group. The interaction between psychological suzhi group and experimental condition was significant [$F(1, 54) = 4.79, p < 0.05, \eta^2 = 0.08$]. The results of multiple comparisons showed that, with an increase in acute stress intensity, the state anxiety of the high psychological suzhi group increased significantly ($p < 0.05$), and the state anxiety of the low psychological suzhi group increased faster than that of the high psychological suzhi group ($p < 0.001$). This result validated H7. The moderating effect of psychological suzhi is illustrated in Fig. 4.

7.3. The moderation of psychological suzhi in the association between acute stress and happiness

The time points of repeated measurement and experimental condition were used as the within-subjects factors, and the psychological suzhi group was used as the between-subjects factor. The results showed that the main effect of time point was significant [$F(3, 52) = 26.99, p < 0.001, \eta^2 = 0.61$], the main effect of experimental condition was not significant [$F(1, 54) = 2.34, p = 0.13, \eta^2 = 0.04$], and the interaction effect of time point and experimental condition was significant [$F(3, 52) = 3.01, p = 0.04, \eta^2 = 0.15$]. The group effect of psychological suzhi was significant [$F(1, 54) = 15.51, p < 0.001, \eta^2 = 0.22$]. Multiple comparisons showed that the happiness level of the high psychological suzhi group was significantly higher than that of the low psychological suzhi group. There was no significant interaction between psychological suzhi group and experimental condition [$F(1, 54) = 2.00, p = 0.16, \eta^2 = 0.04$]. These results suggested that H6 and H8 were not supported. Further details are presented in Table 7.

8. Discussion

Based on the effectiveness of acute stress induction, Study 2 explored the effects of acute stress on the negative and positive mental health indicators of college students, and the moderating effect of psychological suzhi. Compared with the control situation, the subjectively reported stress level of the participants significantly increased in the stressed state, indicating that the TSST-G successfully induced acute stress in the participants. Using state anxiety as a negative indicator of mental health, we found that the level of state anxiety in stressful situations was significantly higher than that in control situations. This finding is consistent with the results of a previous research [22]. Perceived stress mainly refers to an individual adapting to the environment in the process of feeling threatened and rapidly evaluating their mental state, which is the primary reason individuals experience anxiety. In this experiment, the stressful situation placed the participants in the spotlight of attention and evaluation, inducing feelings of threat, challenge, and an uncontrollable sense of social evaluation, thereby causing individual anxiety [62]. Taking happiness level as a positive indicator of mental health, the main effect of the experimental condition was not significant. This may be because although the control situation did not cause strong stress, participants still needed 12 min to read a science essay. Boredom and fatigue can lead to decreased individual happiness.

The experimental study also found that when state anxiety (negative indicator of mental health) was used as the dependent variable in this study, the level of state anxiety in the low psychological suzhi group was significantly higher than that in the high psychological suzhi group. Individuals with high psychological suzhi have clearer and more accurate self-evaluations and self-perceptions, which help them objectively respond to external evaluations. By contrast, individuals with low levels of psychological suzhi are more likely to be overly self-focused, have a greater fear of negative evaluations from others, and activate negative self-evaluations. From the dimension of personality, for example, individuals with strong self-confidence and high fortitude usually think they can cope with threatening events calmly and experience less anxiety. Similarly, individuals with strong adaptability are less nervous and anxious because they can cope calmly with difficulties and challenges. From the perspective of the feature consistency effect, individuals tend to process information consistent with their own characteristics, thereby avoiding inconsistent information. Therefore, individuals

Table 6

The state anxiety levels of the high and low psychological suzhi groups at different measuring time points.

Point in time	High psychological suzhi group		Low psychological suzhi group	
	TSST-G	Control condition	TSST-G	Control condition
Baseline	30.03 ± 5.35	30.60 ± 6.68	37.81 ± 5.64	38.08 ± 7.31
TSST-G preparation	36.13 ± 7.50	31.37 ± 7.23	50.08 ± 6.67	40.73 ± 7.58
After TSST task	36.43 ± 7.55	32.20 ± 8.55	45.73 ± 8.55	38.31 ± 8.42
Rest	27.97 ± 6.31	28.13 ± 6.50	36.39 ± 6.34	33.08 ± 6.66

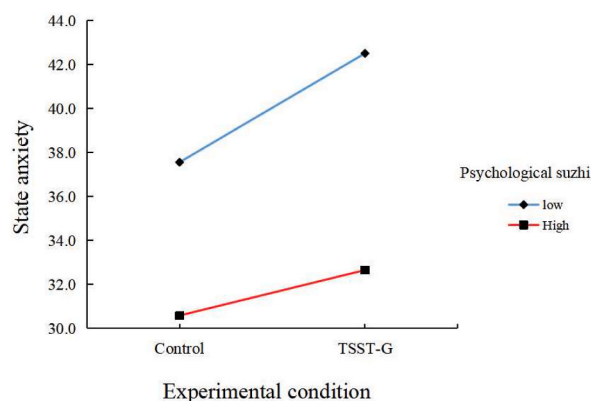


Fig. 4. Interaction between psychological suzhi and experimental condition.

Table 7

The happiness level of high and low psychological suzhi group was measured at different time points.

Point in time	High psychological suzhi group		Low psychological suzhi group	
	TSST-G	Control condition	TSST-G	Control condition
Baseline	7.17 ± 2.91	7.03 ± 3.22	4.89 ± 2.57	4.89 ± 2.92
TSST-G preparation	6.70 ± 2.61	7.00 ± 2.60	3.19 ± 2.37	4.23 ± 2.60
After TSST task	6.67 ± 2.77	6.77 ± 3.11	3.62 ± 2.62	4.62 ± 2.95
Rest	8.13 ± 2.91	7.97 ± 2.40	5.77 ± 2.44	6.27 ± 2.78

with a lower psychological suzhi are more likely to be attracted to negative external information, resulting in more negative emotions [63]. When happiness (positive indicator of mental health) was used as the dependent variable in this study, the happiness level of the high psychological suzhi group was higher than that of the low psychological suzhi group. The adaptation theory of happiness postulates that the generation and change in happiness come, to some extent, from the adaptive response of an individual's emotional system to life events. When individuals adapt to the impact of life events, they feel happy. By contrast, when they cannot adapt, their happiness decreases [22].

In addition, when state anxiety (negative indicator of mental health) was used as the dependent variable in this study, group and experimental condition interaction effect was significant. Psychological suzhi can moderate the impact of acute stress on state anxiety. Further analysis revealed that psychological suzhi can be regarded as a stress-buffering factor. With an increase in acute stress levels, the level of state anxiety of participants with low psychological suzhi increased faster than that of participants with high psychological suzhi. This supports the stress-buffering hypothesis. When happiness (positive indicator of mental health) was used as the dependent variable, the interaction between the group and experimental condition was not significant, which is consistent with the conclusion of Study 1.

9. General discussion

This study found that psychological suzhi could moderate the effects of chronic or acute stress on negative indicators of mental health. According to the diathesis-stress model, vulnerability individuals are more likely to be affected by negative environmental factors and develop psychological problems [56,57]. The same stressful events have a greater impact on college students with low psychological suzhi. To reveal the mechanisms of mental health, researchers have constructed a relationship model between psychological suzhi and mental health. Its core emphasizes that psychological suzhi is the internal key factor determining individual mental health levels, and external risk factors and protective factors play a role through internal psychological suzhi [35]. The model includes sub-models of the forming and acting mechanisms of psychological suzhi. According to the sub-model of the mechanism of psychological suzhi, internal psychological suzhi can not only directly or as an intermediary factor affect individual mental health, but it can also regulate the influence of external risk factors on individual mental health [35]. The results of this study further formalize this model.

It is worth noting that psychological suzhi cannot moderate the impact of chronic or acute stress on positive indicators of mental health. Differences in the role played by psychological suzhi for different mental health indicators in stressful situations. On the one hand, psychological suzhi can act as a protective factor, helping individuals to adapt even after experiencing stress and in the process not experiencing serious problems of psychosocial functioning; on the other hand, there are limitations to the protective effect of psychological suzhi on positive indicators of mental health. This reflects two highly controversial hypotheses in stress research: the stress-buffering hypothesis [64–66] and the stress-vulnerability hypothesis [67–69], both of which have received some support in previous studies. In this study, for negative indicators of mental health, psychological suzhi can serve as a stress-buffering factor to

reduce the negative impact of stress, which supports the stress-buffering hypothesis. However, for positive indicators of mental health, psychological suzhi is a vulnerability factor, and its protective effect decreases in high-stress situations. In summary, this study suggests that psychological suzhi can help individuals effectively relieve anxiety and depression under chronic and acute stress, which provides an important scientific basis for improving college students' ability to cope with stress, cultivating psychological suzhi, and maintaining individual mental health in educational practice.

10. Conclusions

Study 1 has shown that psychological suzhi can moderate the effects of chronic stress on psychological symptoms. However, psychological suzhi had no significant moderating effect on the relationship between chronic stress and life satisfaction. Study 2 has shown that psychological suzhi can moderate the impact of acute stress on state anxiety, but cannot moderate the impact of acute stress on happiness. These two studies suggest that psychological suzhi is an endogenous factor determining college students' mental health, and can help individuals effectively relieve anxiety and depression under chronic and acute stress. It has an important adaptive value in coping with stress. Therefore, while strengthening mental health education of college students, we should also pay attention to the education of psychological suzhi education.

At present, most mental health measurements use single-factor models or the composite indicator DFM, both of which have some problems. This study used a single indicator, DFM, to measure the mental health of college students, which effectively overcame the shortcomings of the other two mental health measurement models. It has also expanded research on methods for measuring mental health. There have been relatively few studies on the impact of acute stress on mental health and the protective role of psychological suzhi, which limits the further development of theories related to psychological suzhi. By measuring mental health based on the DFM, this study examined the protective effects of college students' psychological suzhi on mental health in chronic and acute stress environments. The concept of psychological suzhi was proposed in the context of suzhi education in China. The concept of suzhi education is an academic ideology with Chinese characteristics. Psychological suzhi education is the starting point, destination, and foundation of suzhi education. It is an inherent requirement to conduct research on psychological suzhi to implement suzhi education. This study focused on Chinese college students and explored the mechanisms underlying psychological suzhi, making it a distinctive contribution to psychological studies in the Chinese context. This study aimed to enrich the theoretical foundation of suzhi education practices in China and provide new insights for educational explorations in other countries.

This study also has some limitations. First, it used a cross-sectional research design, making it challenging to establish causal relationships. It cannot reflect the dynamic development characteristics of various indicators or dynamic changes in the relationships between variables. Second, in the study on chronic stress, using only self-assessment scales to measure various variables may have resulted in a response bias. In a study on acute stress, only subjective indicators, such as state anxiety, happiness, stress, and tension, were measured, lacking objective physiological indicators. Previous studies have shown that acute stress activates the sympathetic nervous system and HPA axis, which is manifested by increased heart rate and cortisol secretion. Therefore, future research should consider collecting data from multiple perspectives and increasing the measurement and analysis of heart rate and salivary cortisol levels in acute stress studies. Finally, these two studies only examined the buffering effect of psychological suzhi as a whole, but the role each dimension plays in a specific regulatory process remains unclear. In the future, further in-depth studies should be conducted from a multidimensional perspective.

Ethics declarations

This study was reviewed and approved by Ethics Committee of Binzhou Medical University, with the approval number: 2022-201.

Funding statements

This research was supported by the Shandong Education Science Planning (Grant No. 2020YB016) and the Shandong Province Education and Teaching Research Project (Grant No. 2023JXY026).

Data availability statement

Data associated with the study has not been deposited into a publicly available repository. Data are available on request through the authors' direct contacts, under some terms and conditions.

CRediT authorship contribution statement

Huixin Wang: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **Ruxue Jia:** Writing – original draft, Visualization, Formal analysis, Data curation. **Min Zhang:** Validation, Software, Methodology, Investigation. **Wenyi Fan:** Writing – review & editing, Resources, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to

influence the work reported in this paper.

Acknowledgments

We acknowledge all the participants who took part in this research.

References

- [1] W. Hua, Prevalence of Depression, Anxiety and Stress Among College Students, Master's Thesis, Jilin University, 2020, <https://doi.org/10.27162/d.cnki.gjlin.2020.002885>.
- [2] K.R. Terrell, B.R. Stanton, H.Y. Hamadi, J.W. Merten, N. Quinn, Exploring life stressors, depression, and coping strategies in college students, *J. Am. Coll. Health* (2022) 1–10, <https://doi.org/10.1080/07448481.2022.2061311>.
- [3] N. Hosseinichimeh, A.K. Wittenborn, J. Rick, M.S. Jalali, H. Rahmandad, Modeling and estimating the feedback mechanisms among depression, rumination, and stressors in adolescents, *PLoS One* 13 (9) (2018) e204389, <https://doi.org/10.1371/journal.pone.0204389>.
- [4] R.L. Schneider, E.E. Long, J.J. Arch, B.L. Hankin, The relationship between stressful events, emotion dysregulation, and anxiety symptoms among youth: longitudinal support for stress causation but not stress generation, *Hist. Philos. Logic* 34 (2) (2021) 157–172, <https://doi.org/10.1080/10615806.2020.1839730>.
- [5] S. Yoon, H. Iqbal, S.M. Kim, M. Jin, Phytochemicals that act on synaptic plasticity as potential prophylaxis against stress-induced depressive disorder, *Biomol. Ther.* 31 (2) (2023) 148–160, <https://doi.org/10.4062/biomolther.2022.116>.
- [6] P. Wang, R. Gu, L. Zhang, The relationship between acute stress and risk taking: the moderating effect of ease of excitation, *Acta Psychol. Sin.* 55 (1) (2023) 45–54, <https://doi.org/10.3724/SP.J.1041.2023.00045>.
- [7] S.E. Hobfoll, Conservation of resources: a new attempt at conceptualizing stress, *Am. Psychol.* 44 (3) (1989) 513–524, <https://doi.org/10.1037/0003-066x.44.3.513>.
- [8] D. Zhang, Z. Su, X. Wang, Thirty-years study on the psychological suzhi of Chinese children and adolescents: review and prospect, *Stud. Psychol. Behav.* 15 (1) (2017) 3–11.
- [9] L. Jin, D. Zhang, Z. Zhu, G. Liu, H. Chen, Y. Li, The effect of psychological suzhi on early adolescents' mental health: the mediation role of cognitive reappraisal and positive attributional style, *J. SW. Univ. (Nat. Sci. Ed.)* 43 (7) (2021) 22–29, <https://doi.org/10.13718/j.cnki.xdzk.2021.07.003>.
- [10] X. Zhang, D. Zhang, Y. Lin, et al., The relationship between psychological suzhi and suicidal ideation in adolescents: A moderated mediation model, *J. SW. Univ. (Nat. Sci. Ed.)* 41 (6) (2019) 51–57, <https://doi.org/10.13718/j.cnki.xdzk.2019.06.008>.
- [11] Z. Zhu, W. Tang, G. Liu, D. Zhang, The effect of psychological suzhi on suicide ideation in Chinese adolescents: the mediating role of family support and friend support, *Front. Psychol.* 11 (2020) 632274, <https://doi.org/10.3389/fpsyg.2020.632274>.
- [12] L. Wu, D. Zhang, G. Cheng, T. Hu, Bullying and social anxiety in Chinese children: moderating roles of trait resilience and psychological suzhi, *Child Abuse Negl.* 76 (2018) 204–215, <https://doi.org/10.1016/j.chiabu.2017.10.021>.
- [13] S.P. Antaramian, E.S. Huebner, K.J. Hills, R.F. Valois, A dual-factor model of mental health: toward a more comprehensive understanding of youth functioning, *Am. J. Orthopsychiatry* 80 (4) (2010) 462–472, <https://doi.org/10.1111/j.1939-0025.2010.01049.x>.
- [14] S. Antaramian, Assessing psychological symptoms and well-being, *J. Psychoeduc. Assess.* 33 (5) (2015) 419–429, <https://doi.org/10.1177/0734282914557727>.
- [15] P.J. Greenspoon, D.H. Saklofske, Toward an integration of subjective well-being and psychopathology, *Soc. Indic. Res.* 54 (1) (2001) 81–108, <https://doi.org/10.1023/a:1007219227883>.
- [16] W. Dong, J. Xiong, Y. Wang, An empirical investigation of dual-factor model of mental health in Chinese senior high school students, *Chin. J. Clin. Psychol.* 22 (1) (2014) 88–91, <https://doi.org/10.16128/j.cnki.1005-3611.2014.01.033>.
- [17] X. Chen, Q. Bi, J. Ren, Z. Wang, Y. Qin, A review of the psychological health of nursing undergraduates based on the Dual Model of Mental Health, *Chin. J. Nurs. Educ.* 17 (10) (2020) 953–956, <https://doi.org/10.7666/d.D810089>.
- [18] H. Ding, The Relationship between Social Support and Mental Health of College Students – the Dual-Factor Model of Mental Health, Master's Thesis, Central China Normal University, 2018, <https://doi.org/10.27159/d.cnki.ghzsu.2018.000249>.
- [19] M. Hai, J. Xiong, S. Gong, Y. Qin, M. Gao, A reexamination of the indicators for the dual-factor model of mental health: stability and predictors of mental health, *J. Psych. Sci.* 38 (6) (2015) 1404–1410, <https://doi.org/10.16719/j.cnki.1671-6981.20150618>.
- [20] Y. Cai, The Empirical Research of Nurses Mental Health Based on the Dual-Factor Model, Master's Thesis, Zhejiang Sci-Tech University, 2016, <https://doi.org/10.7666/d.D810089>.
- [21] X. Wang, Q. Xie, D. Zhang, M. Liu, The applicability of the dual-factor model of mental health in Chinese college students and its psychological suzhi: an empirical investigation, *J. Psych. Sci.* 39 (6) (2016) 1296–1301, <https://doi.org/10.16719/j.cnki.1671-6981.20160603>.
- [22] L. Wu, The Influence of Stress on Middle School Students Mental Health and Academic Development: the Protective Effect of Psychological Suzhi, Ph.D. thesis, Southwest University, 2019.
- [23] G.B. Senanayake, C. Arambepola, Understanding chronic stress: a narrative review of literature, *J. Coll. Commun. Phys. Sri Lanka* 25 (1) (2019) 30–36, <https://doi.org/10.4038/jccpsl.v25i1.8196>.
- [24] F.J. Nitsch, M. Sellitto, T. Kalenscher, The effects of acute and chronic stress on choice consistency, *Psychoneuroendocrinology* 131 (2021) 105289, <https://doi.org/10.1016/j.psyneuen.2021.105289>.
- [25] Y. Luo, J. Nian, W. Bao, et al., Acute psychological stress impairs attention disengagement toward threat-related stimuli, *Acta Psychol. Sin.* 52 (1) (2020) 26–37, <https://doi.org/10.3724/SP.J.1041.2020.00026>.
- [26] A.P. Allen, P.J. Kennedy, S. Dockray, J.F. Cryan, T.G. Dinan, G. Clarke, The trier social stress test: principles and practice, *Neurobiol. Stress* 6 (2017) 113–126, <https://doi.org/10.1016/j.ynstr.2016.11.001>.
- [27] A. Nasarudin, E.K. Moeck, P. Koval, Re-appraising stressors from a distance: effects of linguistic distancing on cognitive appraisals and emotional responses to interpersonal conflict, *Cognit. Emot.* 37 (7) (2023) 1281–1289, <https://doi.org/10.1080/02699931.2023.2258570>.
- [28] Y. Luo, W. Lin, J. Wu, S. Qin, Cognitive neuroscience of stress, *Prog. Physiol. Sci.* 44 (5) (2013) 345–353.
- [29] E.J. Hermans, M.J. Henckens, M. Joels, G. Fernandez, Dynamic adaptation of large-scale brain networks in response to acute stressors, *Trends Neurosci.* 37 (6) (2014) 304–314, <https://doi.org/10.1016/j.tins.2014.03.006>.
- [30] Y. Wei, P. Ren, X. Qin, Y. Zhang, F. Luo, C. Chen, Adolescent peer victimization and deliberate self-harm: a three-wave moderated mediation model, *J. Interpers. Violence* 38 (1–2) (2023) NP565–NP587, <https://doi.org/10.1016/j.childyouth.2021.106218>.
- [31] G. Liu, D. Zhang, Y. Pan, et al., Self-concept clarity and subjective social status as mediators between psychological suzhi and social anxiety in Chinese adolescents, *Pers. Indiv. Differ.* 108 (2017) 40–44, <https://doi.org/10.1016/j.paid.2016.11.067>.
- [32] Y. Xu, Interaction Effects of Individual Traits and Environmental Factors on Internalization Problems, Ph.D. thesis, Southeast University, 2018, <https://doi.org/10.27014/d.cnki.gdnau.2018.000238>.
- [33] T. Hu, D. Zhang, The relationship between psychological suzhi and depression of middle school students: the mediating role of self service attribution bias, *J. SW. Univ. (Soc. Sci. Ed.)* 41 (6) (2015) 104–109, <https://doi.org/10.13718/j.cnki.xdzk.2015.06.013>.
- [34] L. Wu, D. Zhang, G. Cheng, T. Hu, D.H. Rost, Parental emotional warmth and psychological suzhi as mediators between socioeconomic status and problem behaviours in Chinese children, *Child. Youth Serv. Rev.* 59 (2015) 132–138, <https://doi.org/10.1016/j.childyouth.2015.09.019>.
- [35] X. Wang, D. Zhang, Looking beyond PTH and DFM: the relationship model between psychological suzhi and mental health, *J. SW. Univ. (Soc. Sci. Ed.)* 38 (6) (2012) 67–74, <https://doi.org/10.13718/j.cnki.xdzk.2012.06.012>.

- [36] J. Huang, X. Yang, Y. Yu, et al., Reliability and validity of Adolescent Self-rating Life Events Checklist among Chinese middle school students living in rural areas, *Chin. J. Sch. Health* 40 (9) (2019) 1353–1355, <https://doi.org/10.16835/j.cnki.1000-9817.2019.09.020>.
- [37] S. Liu, Y. Hu, H. Sun, Mediating effect of neuroticism and coping styles between stress and depression, *Chin. J. Clin. Psychol.* 26 (6) (2018) 1230–1233, <https://doi.org/10.16128/j.cnki.1005-3611.2018.06.040>.
- [38] C.C. Young, M.S. Dietrich, Stressful life events, worry, and rumination predict depressive and anxiety symptoms in young adolescents, *J. Child Adolesc. Psychiatr. Nurs.* 28 (1) (2015) 35–42, <https://doi.org/10.1111/jcap.12102>.
- [39] B. Zuo, X. Zhang, F. Wen, Y. Zhao, The influence of stressful life events on depression among Chinese university students: multiple mediating roles of fatalism and core self-evaluations, *J. Affect. Disord.* 260 (2020) 84–90, <https://doi.org/10.1016/j.jad.2019.08.083>.
- [40] M. Katana, C. Rocke, S.M. Spain, M. Allemand, Emotion regulation, subjective well-being, and perceived stress in daily life of geriatric nurses, *Front. Psychol.* 10 (2019) 1097, <https://doi.org/10.3389/fpsyg.2019.01097>.
- [41] L. Wu, D. Zhang, X. Zhang, G. Cheng, Development of national norms of brief psychological suzhi scale for middle school students, *J. SW. Univ. (Soc. Sci. Ed.)* 43 (6) (2017) 98–105, <https://doi.org/10.13718/j.cnki.xdsk.2017.06.012>.
- [42] H. Liu, C. Zhang, Y. Ji, L. Yang, Biological and psychological perspectives of resilience: is it possible to improve stress resistance? *Front. Hum. Neurosci.* 12 (2018) 326, <https://doi.org/10.3389/fnhum.2018.00326>.
- [43] K. Pacak, M. Palkovits, Stressor specificity of central neuroendocrine responses: implications for stress-related disorders, *Endocr. Rev.* 22 (4) (2001) 502–548, <https://doi.org/10.1210/edrv.22.4.0436>.
- [44] W.G. Moons, N.I. Eisenberger, S.E. Taylor, Anger and fear responses to stress have different biological profiles, *Brain Behav. Immun.* 24 (2) (2010) 215–219, <https://doi.org/10.1016/j.bbi.2009.08.009>.
- [45] Z. Zhen, S. Qin, R. Zhu, C. Feng, C. Liu, Neural mechanism of stress and social decision making under acute stress, *J. Beijing Normal Univ. (Nat. Sci.)* 53 (3) (2017) 372–378, <https://doi.org/10.16360/j.cnki.jbunns.2017.03.020>.
- [46] K.M. Hartikainen, K.H. Ogawa, R.T. Knight, Transient interference of right hemispheric function due to automatic emotional processing, *Neuropsychologia* 38 (12) (2000) 1576–1580, [https://doi.org/10.1016/s0028-3932\(00\)00072-5](https://doi.org/10.1016/s0028-3932(00)00072-5).
- [47] H.J. van Marle, E.J. Hermans, S. Qin, G. Fernandez, From specificity to sensitivity: how acute stress affects amygdala processing of biologically salient stimuli, *Biol. Psychiatr.* 66 (7) (2009) 649–655, <https://doi.org/10.1016/j.biopsych.2009.05.014>.
- [48] R.J. Davidson, J.R. Marshall, A.J. Tomarken, J.B. Henriques, While a phobic waits: regional brain electrical and autonomic activity in social phobics during anticipation of public speaking, *Biol. Psychiatr.* 47 (2) (2000) 85–95, [https://doi.org/10.1016/s0006-3223\(99\)00222-x](https://doi.org/10.1016/s0006-3223(99)00222-x).
- [49] J.A. Coan, J.J. Allen, Frontal eeg asymmetry as a moderator and mediator of emotion, *Biol. Psychol.* 67 (1–2) (2004) 7–49, <https://doi.org/10.1016/j.biopsycho.2004.03.002>.
- [50] C. Kang, Y. Zheng, L. Yang, et al., Prevalence, risk factors and clinical correlates of suicidal ideation in adolescent patients with depression in a large sample of Chinese, *J. Affect. Disord.* 290 (2021) 272–278, <https://doi.org/10.1016/j.jad.2021.04.073>.
- [51] X. Wang, D. Zhang, X. Zhang, Revision of the concise psychological quality scale for college students (health version) and its reliability and validity testing, *J. SW. Univ. (Nat. Sci. Ed.)* 39 (8) (2017) 126–132, <https://doi.org/10.13718/j.cnki.xdsk.2017.08.018>.
- [52] A. Abolghasemi, S.T. Varaniyab, Resilience and perceived stress: predictors of life satisfaction in the students of success and failure, *Procedia - Soc. Behav. Sci.* 5 (2010) 748–752, <https://doi.org/10.1016/j.sbspro.2010.07.178>.
- [53] S.J. Lupien, B.S. McEwen, M.R. Gunnar, C. Heim, Effects of stress throughout the lifespan on the brain, behaviour and cognition, *Nat. Rev. Neurosci.* 10 (6) (2009) 434–445, <https://doi.org/10.1038/nrn2639>.
- [54] E. Diener, R.E. Lucas, C.N. Scollon, Beyond the hedonic treadmill: revising the adaptation theory of well-being, *Am. Psychol.* 61 (4) (2006) 305–314, <https://doi.org/10.1037/0003-066X.61.4.305>.
- [55] S.M. Monroe, A.D. Simons, Diathesis-stress theories in the context of life stress research: implications for the depressive disorders, *Psychol. Bull.* 110 (3) (1991) 406–425, <https://doi.org/10.1037/0033-2909.110.3.406>.
- [56] H. Li, X. Gan, X. Li, T. Zhou, X. Jin, C. Zhu, Diathesis stress or differential susceptibility? testing the relationship between stressful life events, neuroticism, and internet gaming disorder among Chinese adolescents, *PLoS One* 17 (2022) e0263079, <https://doi.org/10.1371/journal.pone.0263079>.
- [57] E. Franck, M.A. Vanderhasselt, L. Goubert, T. Loeys, M. Temmerman, R. De Raedt, The role of self-esteem instability in the development of postnatal depression: a prospective study testing a diathesis-stress account, *J. Behav. Ther. Exp. Psychiatr.* 50 (2016) 15–22, <https://doi.org/10.1016/j.jbtep.2015.04.010>.
- [58] Sylvain Laborde, Anne Brüll, Julian Weber, Lena Sophie Anders, Trait emotional intelligence in sports: a protective role against stress through heart rate variability? *Pers. Indiv. Differ.* 51 (2011) 23–27, <https://doi.org/10.1016/j.paid.2011.03.003>.
- [59] D. Li, W. Zhang, X. Li, N. Li, B. Ye, Gratitude and suicidal ideation and suicide attempts among Chinese adolescents: direct, mediated, and moderated effects, *J. Adolesc.* 35 (1) (2012) 55–66, <https://doi.org/10.1016/j.adolescence.2011.06.005>.
- [60] W. Li, M. Qian, The norm revision of state trait anxiety scale for Chinese college students, *Acta Sci. Naturalium Univ. Pekin.* (1) (1995) 108–112, <https://doi.org/10.13209/j.0479-8023.1995.014>.
- [61] N. Hu, A. Chen, Y. Wang, Q. Li, Z. Xu, Q. Long, Acute stress impairs error monitoring and post-error adjustment, *Acta Psychol. Sin.* 52 (2) (2020) 162–172, <https://doi.org/10.3724/SP.J.1041.2020.00162>.
- [62] E.S. Trent, A.G. Viana, E.M. Raines, et al., Childhood exposure to parental threatening behaviors and anxiety in emerging adulthood: indirect effects of perceived stress, *J. Clin. Psychol.* 79 (9) (2023) 1984–2008, <https://doi.org/10.1002/jclp.23516>.
- [63] J.A. Bargh, W.J. Lombardi, E.T. Higgins, Automaticity of chronically accessible constructs in person x situation effects on person perception: it's just a matter of time, *J. Pers. Soc. Psychol.* 55 (4) (1988) 599–605, <https://doi.org/10.1037/0022-3514.55.4.599>.
- [64] X. Li, H. Lyu, Epidemic risk perception, perceived stress, and mental health during covid-19 pandemic: a moderated mediating model, *Front. Psychol.* 11 (2020) 563741, <https://doi.org/10.3389/fpsyg.2020.563741>.
- [65] J. Dymecka, R. Gerymski, A. Machnik-Czerwik, Fear of covid-19 as a buffer in the relationship between perceived stress and life satisfaction in the polish population at the beginning of the global pandemic, *Health Psychol. Rep.* 9 (2) (2021) 149–159, <https://doi.org/10.5114/hpr.2020.102136>.
- [66] Z. Zhai, G. Liu, S. Li, X. Zhang, Peer victimization and behavior problems in adolescence: mediation and moderation effects of psychological suzhi, *J. SW. Univ. (Soc. Sci. Ed.)* 44 (5) (2018) 90–97, <https://doi.org/10.13718/j.cnki.xdsk.2018.05.011>.
- [67] C. Park, J.D. Rosenblatt, E. Brietzke, Z. Pan, Y. Lee, B. Cao, H. Zuckerman, A. Kalantarova, R.S. McIntyre, Stress, epigenetics and depression: a systematic review, *Neurosci. Biobehav. Rev.* 102 (2019) 139–152, <https://doi.org/10.1016/j.neubiorev.2019.04.010>.
- [68] L.M. Gutman, H. Joshi, I. Schoon, Developmental trajectories of conduct problems and cumulative risk from early childhood to adolescence, *J. Youth Adolesc.* 48 (2) (2019) 181–198, <https://doi.org/10.1007/s10964-018-0971-x>.
- [69] E. Vanderbilt-Adriance, D.S. Shaw, Conceptualizing and re-evaluating resilience across levels of risk, time, and domains of competence, *Clin. Child Fam. Psychol. Rev.* 11 (1–2) (2008) 30–58, <https://doi.org/10.1007/s10567-008-0031-2>.