

The Effect of Emotion Regulation on Non-Suicidal Self-Injury Among Adolescents: The Mediating Roles of Sleep, Exercise, and Social Support

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Purpose: To explore the relationship between adolescents' emotion regulation ability and non-suicidal self-injury (NSSI) behavior and the role of sleep, exercise, and social support in this relationship.

Methods: A total of 2573 adolescents were investigated with the Cognitive Emotion Regulation Scale, the Social Support Scale for Children and Adolescents, the Ottawa Self-Injury Questionnaire, and the Self-Made Living Condition Questionnaire, and path analysis was conducted based on the structural equation model (SEM).

Results: 1) There was a significant correlation between emotion regulation ability and NSSI behavior; 2) sleep and social support played a mediating role between emotion regulation ability and NSSI behavior; and 3) sleep modulated the direct effect of negative emotion regulation ability on NSSI, while exercise modulated the direct effect of positive emotion regulation ability on NSSI, which indicated that sleep and exercise could effectively alleviate NSSI behavior caused by the lack of emotion regulation in adolescents.

Keywords: emotion regulation ability, non-suicidal self-injury, NSSI, structural equation model, SEM

Introduction

Adolescence is a transitional period in one's physical, cognitive, social, and emotional development.¹ Adolescents are in a critical period of physical and psychological growth, turbulence, and chaos.² During this period, they are faced with psychological and behavioral problems such as identity development, the desire to be accepted and recognized by a group, and adaptation to social life.^{3,4} Non-suicidal self-injury (NSSI) is an act in which an individual intentionally harms their own body tissue, but without suicidal intent.⁵ In western countries such as European nations, North America or Australia, the incidence of NSSI behavior of adolescents ranges from 6.2% to 45%.⁶⁻¹⁰ In China, the incidence of NSSI behavior among adolescents is 5.4%-57.4%.¹¹⁻¹⁵ The NSSI problem of Chinese adolescents is serious and needs to be addressed urgently. Therefore, it is necessary to strengthen and widen research to provide support for the prevention and intervention of NSSI behavior of adolescents, and to promote the development of their mental health.

The Relationship Between Emotion Regulation Ability and NSSI

The experiential avoidance model believes that the main function of NSSI is to regulate negative emotional experience,¹⁶ or that individuals adopt NSSI behavior to avoid negative emotional experiences.¹⁷ Emotion regulation refers to the individual's recognition, understanding, and acceptance of their own emotional experience, and flexible use of strategies for appropriate behavior.¹⁸ When encountered with stressful events, NSSI people have problems experiencing and expressing their emotions, and are more likely to produce a higher level of emotional arousal. They are not able to exercise effective strategies to adjust their behavioral responses, which produces NSSI behavior.

Victor and Klonsky (2013) found that individuals with NSSI behavior suffered greater negative emotions than those without NSSI behavior.¹⁹ In terms of problem avoidance behavior, people tend to use NSSI as an effective coping strategy due to the lack of other coping strategies.²⁰ In terms of coping behavior, those with repetitive NSSI are highly likely to use avoidance or emotion-focused coping styles.²¹

Therefore, the following hypothesis is proposed:

H1: emotion regulation ability will affect adolescent NSSI behavior.

The Mediating Effect of Sleep

Sleep quality is often overlooked as a predictor of NSSI behavior. Nighttime sleep is a period when adolescents undergo many psychological and biological changes in their bodies, which may lead to sleep deprivation.²² The key mechanism by which sleep deprivation affects mental health is emotional dysregulation. Studies have shown that individual transformations occurring in the central nervous system of adolescents may not necessarily have a direct impact on sleep patterns, but are highly likely to alter or influence mood or emotion regulation activities, which are critical to the interaction of adolescent sleep patterns.²³

Sleep deprivation may ultimately lead to psychological and emotional instability in adolescents,²⁴ thereby limiting their ability to confront certain emotional weaknesses.²⁵ Adolescents can regulate their moods or emotions in many ways, and sleep deprivation may make them vulnerable to various measures of adaptive regulation of emotional distress, such as deliberately regulating their emotions by engaging in NSSI or compensating for sleep deprivation through NSSI behavior.²⁶ Sleep quality mediates the relationship between depressed mood and NSSI behavior.²⁷

Multiple sleep variables, such as short sleep time, insomnia or frequent nightmares, are associated with and are important risk factors for NSSI behavior.^{28,29} Studies have found that most individuals with NSSI behavior have sleep difficulties.^{30,31} The researchers also demonstrated through logistic regression models that poor sleep quality was associated with NSSI (OR=2.18, 95% CI=1.37–3.47), and that it affected the mental health of adolescents.^{32–35} Park, Yoo and Kim also found that adolescents with sleep problems were highly likely to have NSSI than those who slept well (OR=1.58, $p=0.03$), and that less than four hours of sleep increased the likelihood of NSSI.³⁶

NSSI may also be a complex and serious challenge that may not be only solved by nighttime sleep. Sleep deprivation in adolescents can impair mood or emotional regulation, which is a key role of NSSI. It is necessary to further explore whether there is a direct correlation between sleep quality and individual emotion regulation ability and NSSI behavior.

Therefore, the following hypotheses are proposed:

H2: sleep has an impact on adolescents' NSSI behavior.

H3: sleep is related to adolescents' emotion regulation.

H4: sleep quality plays a mediating role between emotion regulation and adolescents' NSSI behavior.

The Mediating Effect of Exercise

Sports may affect emotional regulation, thereby affecting NSSI behavior.^{34,37–39} The level of physical exercise may affect an individual's hormonal balance, and subsequently, their emotional state.^{40,41} A study explored the association between exercise and NSSI, and established that exercise is inversely related to NSSI frequency,⁴² and exercise interventions of different intensities can reduce physical and mental health problems.⁴³ There may be an association between physical inactivity and depression, which, in turn, affects NSSI.⁴²

Lack of exercise may be associated with NSSI behavior, and may affect sleep quality.⁴¹ Long-term sleep deprivation can lead to serious mental health problems.⁴⁴ Kline pointed out that insufficient sleep may affect physical activity.⁴⁵ Therefore, the relationship between sleep and exercise is bidirectional.⁴⁶ The interaction between sleep and physical activity may regulate NSSI behavior in adolescents.⁴⁷

Physical exercise is a non-pharmaceutical intervention for sleep disorders, which does not incur many costs.⁴⁸ This approach is also readily available, and provides a complementary approach to improving sleep quality and NSSI behavior,

which can be used as a reference for future interventions for adolescent NSSI behavior. Therefore, it is necessary to further analyze how physical exercise affects the relationship between emotion regulation ability and NSSI behavior.

Therefore, the following hypotheses are proposed:

H5: exercise will affect adolescents' NSSI behavior.

H6: exercise is related to adolescents' emotion regulation.

H7: exercise level plays a mediating role between emotion regulation and adolescents' NSSI behavior.

The Moderating Effect of Social Support

Social support may influence NSSI behavior, and increasing social support may decrease the likelihood of NSSI behavior.⁴⁹ NSSI behavior may be influenced by peers, and peer relationships play an important role in the growth and development of adolescents. Positive peer relationships⁵ or negative events in peer relationship⁵⁰ may influence the occurrence of NSSI behavior in adolescents. However, poor peer relationships may also contribute to increased NSSI behavior.⁵¹ For example, specific social behavior induction among peers,⁵² discussion or encouragement of this behavior with peers,⁵³ and risk-taking behavior via imitation learning or ostentation⁵⁴ may also lead to the occurrence of NSSI behavior.

School or social environment may affect social adaptability of adolescents, which may lead to NSSI behavior occurrence in adolescents.^{3,55,56} Positive school functioning has a protective effect on NSSI, while future NSSI behavior is highly likely in students who feel disconnected from or dissatisfied with school, and those who feel that teachers are unfair.⁵⁷ Positive family relationships may form protective factors that prevent or buffer the effects of adolescents' NSSI behaviors.⁵⁸⁻⁶¹ Peer and family support may moderate interpersonal problems and mitigate NSSI behaviors. For example, Adrian et al established structural equation models (SEM) to show that emotional dysregulation is the underlying process that puts adolescents at risk for NSSI, and mediated the effects of interpersonal problems through home and peer domains.⁶² Parental bonding, bonding with non-parent adults, and school safety emerged as strong protective factors.⁶¹

Therefore, the following hypotheses are proposed:

H8: social support will impact adolescents' NSSI behavior.

H9: social support is significantly related to adolescents' emotion regulation.

H10: the level of social support plays a mediating role between emotion regulation and adolescents' NSSI behavior.

Methods

Study Participants

A total of 2573 middle school students from 48 classes (24 junior high schools and 24 senior high schools) in 12 middle schools in Guangxi were selected by offline cluster stratified sampling. Questionnaires were distributed and collected by trained head teachers, psychological teachers and professional students on the spot. In this study, 2400 questionnaires were collected, and 2344 valid questionnaires were obtained after deleting the invalid questionnaires such as those with consistent responses and multiple missing answers, with an effective rate of 97.67%. There were 1142 boys and 1202 girls in the survey. The participants were between 11 and 19 years of age (15.76 ± 2.58). Of them, 411 were in the seventh grade, 427 in the eighth grade, 332 in the ninth grade, 466 in the tenth grade, 447 in the eleventh grade and 261 in the twelfth grade.

Before the questionnaire survey, the parents of the interviewees were informed of the contents of the survey by the investigator and their head teacher, and their consent was obtained. Simultaneously, the interviewees were briefed on the subject, content, and the use of the questionnaire, and informed consent was obtained (the survey could also be terminated at any time according to their wishes). All the interviewees were required to maintain anonymity to protect their privacy. This study was reviewed and approved by the Human Research Ethics Committee of the Sultan Idris University of Education, Malaysia.

Measuring Instrument

Cognitive Emotion Regulation Questionnaire (CERQ)

It was compiled by Granifski after synthesizing the previous literature related to emotional coping theory. Zhu et al revised and tested the reliability and validity of the Chinese version of Cognitive Emotion Regulation Questionnaire (CERQ).⁶³ There are 36 items in the scale, including two dimensions of positive regulation (including five items of acceptance, positive refocusing, positive reappraisal, rational thinking, and refocus on planning, scored in the opposite direction) and negative regulation (four contents of rumination, self-censure, censure of others, and catastrophizing), scored on five points; the higher the score, the lower the level of regulation. In this study, the combined reliability (CR) of the negative cognitive emotion regulation subscale was 0.95, the convergent validity (AVE) was 0.56, and there was good fit index of the confirmatory factor test: $\chi^2/DF = 12.24$, CFI = 0.94, TLI = 0.92, RMSEA = 0.069. The positive cognitive emotion regulation subscale had a combined reliability (CR) of 0.96, convergent validity (AVE) of 0.53, and good fit measures for confirmatory factor tests: $\chi^2/DF = 15.03$, CFI = 0.90, TLI = 0.88, RMSEA = 0.077.

Child and Adolescent Social Support Scale

The Chinese version of the Child and Adolescent Social Support Scale was first compiled by Malecki and Demaray (updated in 2000) and revised by Luo, Chen and Mu.⁶⁴ The scale consists of 60 items, including five sub-scales (parents, teachers, classmates, friends, and school people). A six-point score was used; the higher the score, the higher the degree of support. In this study, the combined reliability (CR) was 0.98, the convergent validity (AVE) was 0.73, and there was good fit index of the confirmatory factor test: $\chi^2/DF = 14.88$, CFI = 0.95, TLI = 0.94, RMSEA = 0.077.

Ottawa Self-Injury Inventory

The Chinese version of the Ottawa Self-Injury Inventory was revised by Cloutier and Nixon on the basis of Epstein, and revised and tested by Zhang et al.^{52,65} The questionnaire consists of 28 items, including the frequency of NSSI, the location of injury, the way of injury, impulse feeling, motivation, the role of releasing negative emotions, potential addiction characteristics and resistance strategies, and seeking treatment. Likert Level 2 (Yes, No) and Level 5 (0, 1, 2, 3, 4) assessment methods were adopted. In this study, the combined reliability (CR) was 0.91, the convergent validity (AVE) was 0.72, and there was good fit index of the confirmatory factor tests: $\chi^2/df=14.23$, CFI=0.99, TLI=0.99, RMSEA=0.075.

Living Condition Questionnaire

A self-designed Living Condition Questionnaire was used. Sleep status comprises sleep duration, sleep environment, sleep quality, and sleep effect, which is scored on five points, and the higher the score, the better the sleep quality. Physical exercise status consists of exercise duration, interest, exercise intensity, and exercise effect, which is scored on five points. The higher the score, the better the exercise level. In this study, the combined reliability of the sleep status questionnaire was 0.61, the convergent validity (AVE) was 0.32, and the confirmatory factor analysis fit index was good: $\chi^2/df=4.31$, CFI=0.99, TLI=0.98, RMSEA=0.038. The combined reliability of the physical exercise status questionnaire was 0.68, the convergent validity (AVE) was 0.34, and the confirmatory factor analysis fit index was good: $\chi^2/df=17.87$, CFI=0.98, TLI=0.93, RMSEA=0.085.

Data Analysis

SPSS 25.0 (IBM, Armonk, NY, USA) was used for descriptive statistics and correlation analysis. Amos 23.0, SPSS 25.0 and its plug-in Process v3.5 (Andrew F. Hayes) were used to test reliability and validity. Common method bias test, confirmatory factor analysis, mediating effect, and moderating effect tests were conducted.

Results

Common Method Bias Test

Harman's single factor was used to test the common method bias of the questionnaire used in this study, and the remaining items were analyzed by factor analysis. The data results showed 18 common factors whose eigenvalues were greater than one, and the first common factor explained 21.90% of the total variance. It was significantly less than the critical value of 40%, so there was no common method bias effect in this study.

Structural Equation Model Analysis

Path Analysis

Emotion experiential avoidance theory suggests that adolescents' emotion regulation is related to NSSI behavior. In addition, research has demonstrated that parental support, sleep quality, and exercise level can affect the emotional regulation ability and NSSI behavior of adolescents. This study establishes an SEM to test the relationship between adolescent emotion regulation, parental support, sleep quality, exercise level, and NSSI behavior (see Figure 1). The results show that the fitting indexes of the SEM meet the standard: $\chi^2/DF = 7.70$, CFI = 0.90, TLI = 0.88, SRMR = 0.03, RMSEA = 0.053 (< 0.08). By observing the path coefficients CR and P among the variables in the SEM, the results showed that the 11 hypothetical paths in the model were supported (see Table 1).

Among them, positive emotion regulation had a great influence on social support ($\beta=1.155$, $P < 0.001$), exercise ($\beta=0.930$, $P < 0.001$), sleep ($\beta=0.957$, $P < 0.001$); negative emotion regulation influenced social support ($\beta=-0.931$, $P < 0.001$), exercise ($\beta=-0.840$, $P < 0.001$), and sleep ($\beta=-1.085$, $P < 0.001$). Positive emotion regulation ($\beta=-1.176$, $P < 0.001$), negative emotion regulation ($\beta=1.306$, $P < 0.001$), sleep ($\beta=0.125$, $P < 0.05$), exercise ($\beta=0.079$, $P < 0.053$), and social support ($\beta=0.198$, $P < 0.001$) had a significant effect on NSSI.

Intermediary Model Test

Zhao, Lynch and Chen suggested that the SEM method is the best framework for the analysis of mediation effects.⁶⁶ The bootstrapping method is used to generate the empirical sample distribution of the statistic (mediating effect), from which the confidence interval and standard error are obtained to judge the statistical significance of the mediating effect.⁶⁷ Based on the research hypothesis in this study, a self-compiled code was inserted to calculate the mediating effect values of parental support, sleep quality, and exercise level between emotion regulation type and NSSI. Table 2 shows the results.

Mediating effects of three variables were seen between negative emotion regulation and NSSI. First, the mediating effect of sleep on NSSI ($\beta=-0.135$, $p < 0.05$), and the effect of negative emotion regulation on sleep ($\beta=-1.085$, $p < 0.001$) were significant. Second, after adding exercise, the mediating effect of exercise on NSSI was not significant ($\beta=-0.066$, $p > 0.05$), while the effect of negative emotion regulation on exercise ($\beta=-0.840$, $p < 0.001$), and the total effect of negative emotion regulation on NSSI ($\beta=1.306$, $p < 0.001$) were significant. Finally, when social support was added, the mediating effect of social support on NSSI ($\beta=-0.184$, $p < 0.001$), and the effect of negative emotion regulation on social support ($\beta=-0.931$, $p < 0.001$) were significant.

Mediating effects of three different variables were seen between positive emotion regulation and NSSI. First, the mediating effect of sleep on NSSI ($\beta=0.119$, $p < 0.05$), and the effect of positive emotion regulation on sleep ($\beta=0.957$, $p < 0.001$) were significant. Second, after adding exercise, the mediating effect of exercise on NSSI was not significant ($\beta=0.074$, $p > 0.05$), while the effect of positive emotion regulation on exercise ($\beta=0.930$, $p < 0.001$), and the total effect of positive emotion regulation on NSSI ($\beta=-1.176$, $p < 0.001$) were significant; Finally, social support had a significant mediating effect on NSSI ($\beta=0.229$, $p < 0.001$), and positive emotion regulation had a significant effect on social support ($\beta=1.155$, $p < 0.001$).

In addition, the upper and lower limits of the confidence intervals of the direct and mediating effects of social support and sleep on negative emotion regulation, positive emotion regulation, and NSSI do not contain 0 (see Table 2), thus indicating that positive and negative emotion regulation can not only directly affect NSSI, but also affect NSSI through the mediating effects of social support and sleep.

Adjustment Model Fitting Test

To test the moderating effect of parental support, sleep quality, and exercise on the relationship between two emotion regulation styles and NSSI, this study established multiple regression analysis models. In these models, negative and positive emotion regulation were independent variables; parental support, sleep quality, and exercise were moderators; and NSSI was the dependent variable. Therefore, 13 multiple regression models were established. The specific analysis steps are as follows: first, the model introduces a control variable (M1); second, the model introduces a control variable, an independent variable, and an adjustment variable (M2, M4, M6, M8, M10, M12); third, the model introduces control variables, independent variables, moderators, and interaction terms between independent and moderators (M3, M5, M7, M9, M11, M13).

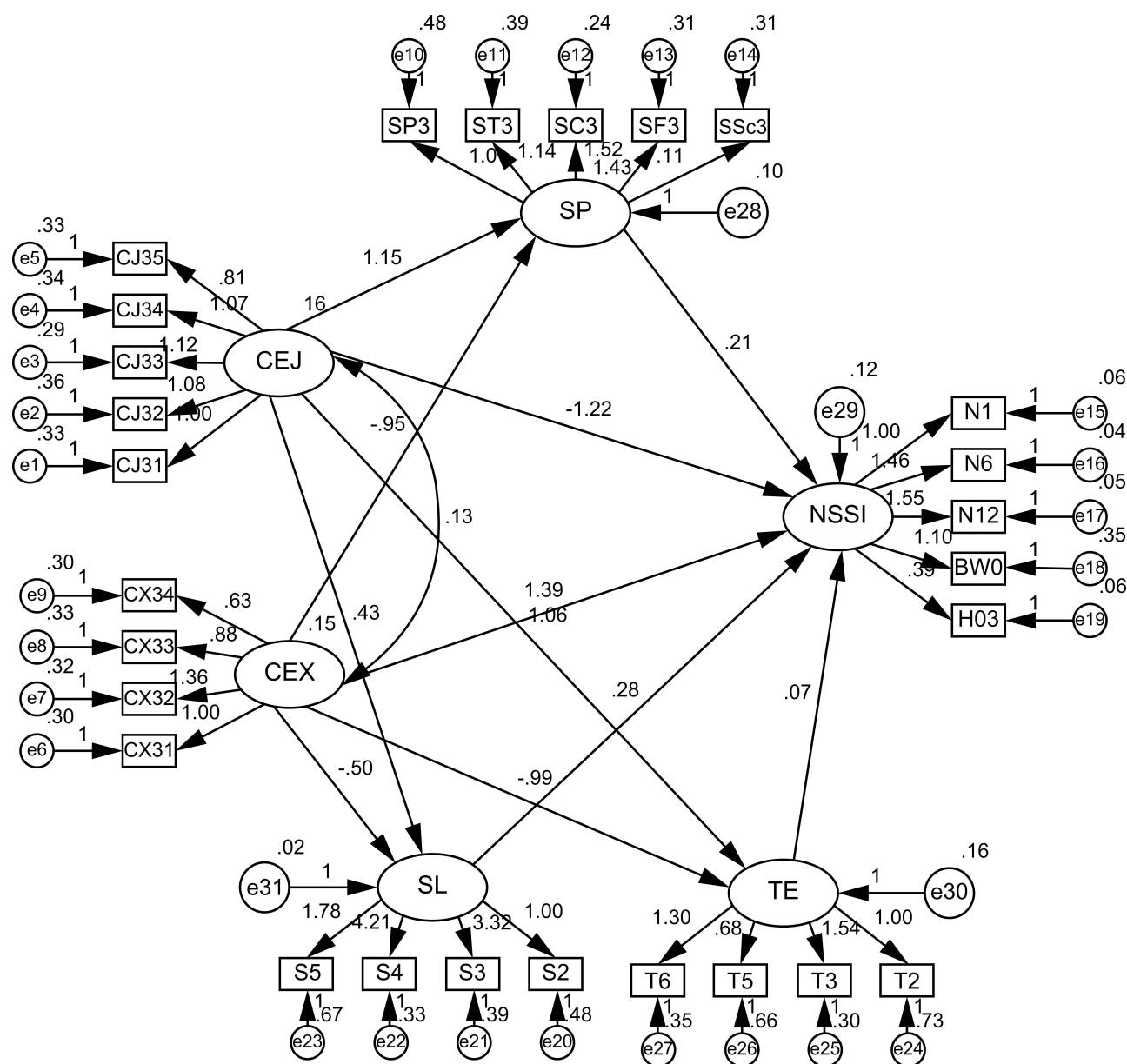


Figure 1 Structure path diagram.

Abbreviations: CEX, negative emotion regulation; CEJ, positive emotion regulation; SP, social support; SL, sleep; TE, exercise; NSSI, non-suicidal self-injury.

First, the influence of control variables on NSSI was analyzed. The results showed that the regression coefficients of the control variables in Model M1 were significant, indicating that the effects of sex (Gen), class type (Key), age (Age), and academic achievement (Ace) on NSSI were significant (see Model M1 in Table 3).

Second, moderating effects of different independent variables were found between negative emotion regulation and NSSI (see Table 3):

In Model M3, the interaction of the independent variables (social support and negative emotion regulation) had no significant effect on NSSI ($\beta = -0.063$, $p > 0.05$).

In Model M5, the independent variables of negative emotion regulation ($\beta = 0.612$, $P < 0.001$), and sleep ($\beta = 0.094$, $P < 0.05$) had a significant effect on NSSI and the regression coefficient of independent variable interaction term ($\beta = -0.445$, $P < 0.001$), indicating that the interaction term has a significant impact on NSSI. Further analysis found that the R^2

Table 1 Path Coefficient of Structural Equation Model

Assuming That Path			Estimate (std.)	S.E.	C.R.	P	Hypothesis
SP	←	CEJ	1.155	0.103	11.115	0.000	Supported
TE	←	CEJ	0.930	0.108	9.829	0.000	Supported
SL	←	CEJ	0.957	0.058	7.470	0.000	Supported
SP	←	CEX	-0.931	0.100	-9.465	0.000	Supported
TE	←	CEX	-0.840	0.109	-9.035	0.000	Supported
SL	←	CEX	-1.085	0.065	-7.808	0.000	Supported
NSSI	←	SP	0.198	0.055	3.758	0.000	Supported
NSSI	←	CEX	1.306	0.234	5.923	0.000	Supported
NSSI	←	CEJ	-1.176	0.230	-5.287	0.000	Supported
NSSI	←	SL	0.125	0.118	2.416	0.014	Supported
NSSI	←	TE	0.079	0.037	1.932	0.056	Not supported

Abbreviations: CEX, negative emotion regulation; CEJ, positive emotion regulation; SP, social support; SL, sleep; TE, exercise; NSSI, non-suicidal self-injury; Estimate (std.), Standardized Regression Weights.

Table 2 Intermediary Effect Test

Assuming That Path	Estimate (std.)	Lower	Upper	P	Hypothesis
CEX→NSSI	1.306	0.821	2.208	0.000	Supported
CEJ→NSSI	-1.176	-2.084	-0.672	0.000	Supported
CEX→SP→NSSI	-0.184	-0.410	-0.069	0.000	Supported
CEX→SL→NSSI	-0.135	-0.361	-0.025	0.013	Supported
CEX→TE→NSSI	-0.066	-0.196	0.001	0.052	Not supported
CEJ→SP→NSSI	0.229	0.090	0.484	0.000	Supported
CEJ→SL→NSSI	0.119	0.021	0.331	0.013	Supported
CEJ→TE→NSSI	0.074	-0.001	0.211	0.054	Not supported

Notes: Lower, lower confidence interval; Upper, upper confidence interval.

Abbreviations: CEX, negative emotion regulation; CEJ, positive emotion regulation; SP, social support; SL, sleep; TE, exercise; NSSI, non-suicidal self-injury.

of Models M4 and M5 are 0.091 and 0.089, respectively, indicating that the explanatory ability of the model has been improved ($P < 0.001$). Therefore, sleep has a significant regulatory effect on the relationship between negative emotion regulation ability and NSSI.

In Model M7, the independent variable of negative emotion regulation had a significant effect on NSSI ($\beta = 0.440$, $P < 0.001$), but exercise had no significant effect on NSSI ($\beta = 0.059$, $P > 0.05$).

The moderating effects of different independent variables were found between positive emotion regulation and NSSI (see Table 3).

In Model M9, the interaction of independent variables social support and positive emotion regulation had no significant effect on NSSI ($\beta = -0.060$, $p > 0.05$).

In Model M11, the interaction of independent variable sleep and positive emotion regulation had a marginal significant effect on NSSI ($\beta = -0.055$, $p > 0.05$).

In Model M13, the independent variable of positive emotion regulation had no significant effect on NSSI ($\beta = -0.086$, $P > 0.05$), exercise had a significant effect on NSSI ($\beta = -0.215$, $P < 0.001$), but the regression coefficient of independent variable interaction term ($\beta = 0.200$, $P < 0.05$), had a significant impact on NSSI. Further analysis found that the R^2 of Models M12 and M13 are 0.031 and 0.032, respectively, thus indicating that the explanatory ability of the model has been improved ($P < 0.05$). Therefore, the exercise of regulatory variables has a significant regulatory effect on the relationship between positive emotion regulation ability and NSSI.

Table 3 Regulation Effect Test

Variable	NSSI												
	M 1	M 2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13
Gen	0.097***	0.100***	0.099***	0.084***	0.088***	0.066**	0.067**	0.101***	0.101***	0.083***	0.083***	0.063**	0.064**
Key	−0.063**	−0.054**	−0.054**	−0.038	−0.035	−0.042*	−0.039	−0.070***	−0.069***	−0.050*	−0.050*	−0.056**	−0.056**
Age	−0.053*	−0.074***	−0.073***	−0.093***	−0.087***	−0.076***	−0.076***	−0.062**	−0.063**	−0.089***	−0.089***	−0.065**	−0.065**
Aca	−0.089***	−0.052*	−0.051*	−0.044*	−0.033	−0.066***	−0.065***	−0.073***	−0.073***	−0.057**	−0.058**	−0.087***	−0.087***
CEX		0.230***	0.280***	0.205***	0.612***	0.227***	0.440***						
CEJ								0.065***	0.102	0.041*	−0.001	−0.053**	−0.086
SP		−0.090***	−0.056					−0.100**	−0.063				
SL				−0.144***	0.094*					−0.179***	−0.212***		
TE						−0.082***	0.059					−0.093***	−0.215***
CEX*SP			−0.063										
CEX*SL					−0.445***								
CEX*TE							−0.260***						
CEJ*SP									−0.060				
CEJ*SL											0.055		
CEJ*TE													0.200*
R ²	0.021	0.080	0.080	0.091	0.104	0.078	0.083	0.032	0.032	0.052	0.053	0.031	0.032
ΔR ²	0.020	0.078	0.078	0.089	0.101	0.076	0.080	0.029	0.029	0.050	0.050	0.028	0.030
F	12.79***	74.53***	0.85	89.28***	33.06***	72.26***	12.08***	12.62***	0.46	38.23***	0.32	10.96***	4.65*

Notes: Statistically significant values * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Abbreviations: CEX, negative emotion regulation; CEJ, positive emotion regulation; SP, social support; SL, sleep; TE, exercise; NSSI, non-suicidal self-injury; M1-M12, Model 1-Model 12.

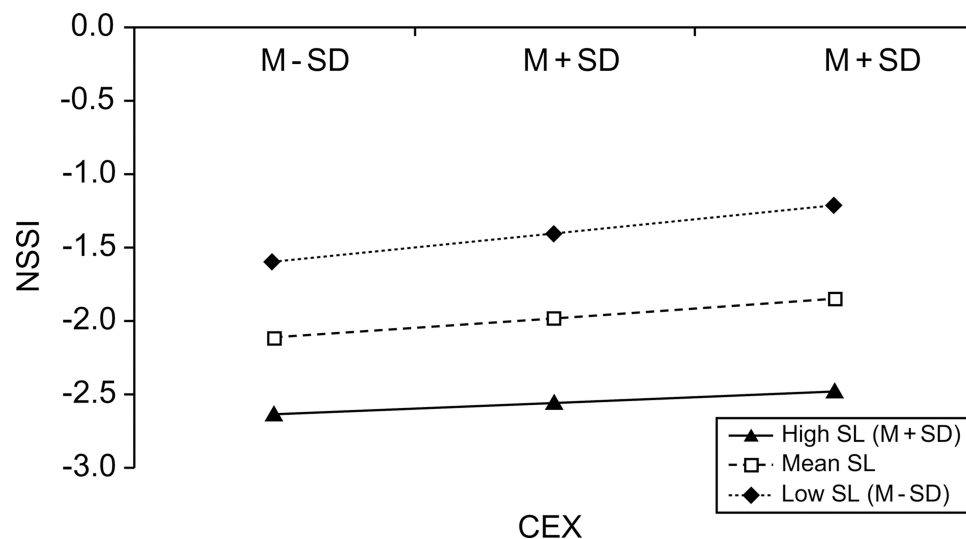


Figure 2 Regulatory effect of sleep on negative emotion and NSSI.

Abbreviations: CEX, negative emotion regulation; SL, sleep; NSSI, non-suicidal self-injury.

Finally, according to the regulation results in the significant regulation effect model, the regulation effect trend of different independent variables between emotion regulation and NSSI will be analyzed by drawing a simple regulation effect diagram.

In Model M5, sleep quality had a significant moderating effect between negative emotion regulation and NSSI behavior. As seen in the regulation effect diagram (Figure 2), in the case of high sleep quality (95% confidence interval [0.120, 0.206], excluding 0), the positive effect of negative emotion regulation on NSSI behavior is weak, while in the case of moderate sleep quality (95% confidence interval [0.149, 0.241], excluding 0), or low sleep quality (95% confidence interval [0.164, 0.292], excluding 0), the positive effect of negative emotion regulation on NSSI behavior gradually increased.

In Model M13, exercise had a significant moderating effect between positive emotion regulation and NSSI behavior. It can be seen in the regulation effect diagram (Figure 3) that the effect of positive emotion regulation ability on NSSI behavior is weak under the condition of high exercise level (95% confidence interval [-0.067, 0.028], including 0), while

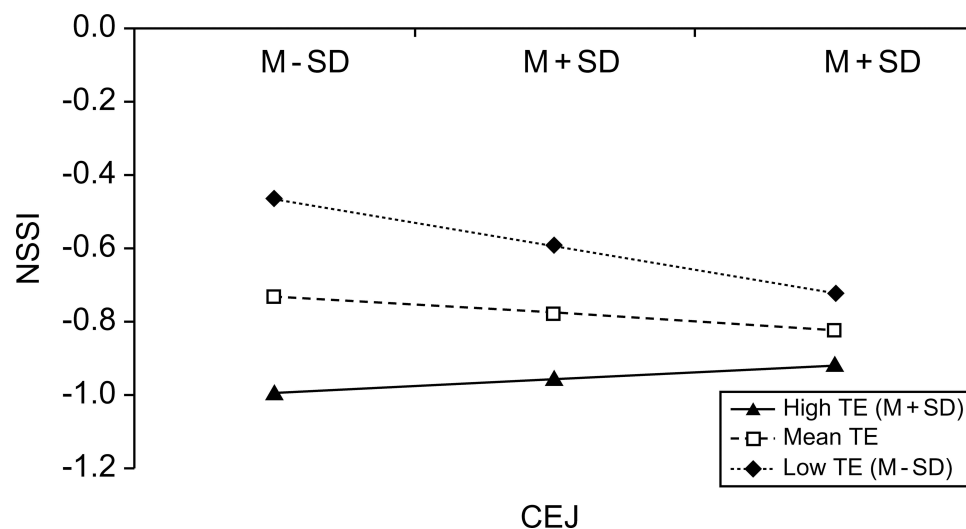


Figure 3 Regulation of exercise on positive emotion and NSSI.

Abbreviations: CEJ, positive emotion regulation; TE, exercise; NSSI, non-suicidal self-injury.

under the condition of moderate exercise level (95% confidence interval $[-0.124, -0.032]$, excluding 0) or low exercise level (95% confidence interval $[-0.179, -0.054]$, excluding 0), the effect of positive emotion regulation on NSSI behavior gradually weakened.

Discussion

Relationship Between Emotion Regulation and NSSI

The results showed a significant correlation between emotion regulation and adolescents' NSSI behavior. Negative emotion regulation was positively correlated with NSSI behavior ($\beta = 1.306, p < 0.001$), while positive emotion regulation was negatively correlated with NSSI behavior ($\beta = -1.176, p < 0.001$). Hypothesis H1 was established. This result shows a significant correlation between emotion regulation and adolescent NSSI behavior, and from the correlation value, negative emotion regulation has a greater impact than positive emotion regulation, which indirectly proves that NSSI is a strategy and way for adolescents to cope with emotions or behaviors.²⁰

Relationship of Sleep with Emotion Regulation and NSSI

The results showed a significant correlation between sleep and adolescent NSSI behavior ($\beta=0.125, P<0.05$), and the hypothesis H2 was established, which was consistent with the results of the previous studies.^{26,28,29} Second, there was a significant positive correlation between positive emotion regulation and sleep ($\beta=0.957, P<0.001$). There was a significant negative correlation between negative emotion regulation and sleep ($\beta=-1.085, P<0.001$), assuming that H3 is true, which shows that sleep affects adolescents' emotional regulation.²⁴ In addition, it was found that sleep had significant mediating effects on negative emotion regulation ($\beta=-0.135, P<0.05$), positive emotion regulation ($\beta=0.119, P<0.05$) and NSSI, indicating that sleep mediates between emotion regulation and adolescent NSSI behavior.²⁷ However, in terms of the regulatory effect of sleep on emotion regulation and adolescent NSSI behavior, it played a greater regulatory role in negative emotion regulation and NSSI behavior ($\beta=-0.445, P<0.001$), and the regulatory effect was significant in different levels of sleep quality. Therefore, sleep plays a mediating role between emotion regulation and adolescent NSSI behavior, and the hypothesis H4 holds.

Relationship of Exercise with Emotion Regulation and NSSI

The results show that exercise has a certain correlation with adolescent NSSI behavior, showing a marginal significant effect ($\beta=0.079, P<0.053$), assuming H5 holds, which is similar to the results of Boone and Brausch.⁴² Second, through the path analysis of exercise and emotion regulation, it was found that exercise has a significant correlation with positive emotion regulation ($\beta=0.930, P<0.001$) and negative emotion regulation exercise ($\beta=-0.840, P<0.001$). It is assumed that H6 is established, which is consistent with the results of previous studies.^{40,41} Due to the necessity for fitting the SEM, there is no direct relationship between exercise and sleep. Using the total score of exercise and sleep, there is a significant positive correlation between exercise and sleep in adolescents ($r=0.248, P<0.001$), which is consistent with the results of O'Connor, Rasmussen and Hawton.⁴¹ Further analysis of the mediating effect of exercise on emotion regulation and adolescent NSSI behavior shows that while exercise can regulate negative ($\beta=-0.066, P>0.05$) and positive emotions ($\beta=0.074, P>0.05$), the mediating effect of NSSI is not significant, and the hypothesis H7 is not tenable. However, further examination of the regulatory effect of exercise on emotion regulation and adolescent NSSI behavior shows that exercise has a significant regulatory effect on positive emotion regulation and adolescent NSSI behavior ($\beta=0.200, P<0.05$), and positive emotion regulation plays a highly significant role in adolescents with low and medium level of exercise. Thus, there is a difference in the moderating effect of exercise level between positive emotion regulation and adolescent NSSI behavior. Therefore, while intervening in adolescents' behavior by adjusting their exercise level, attention must be given to identify adolescents with different exercise levels and highlight the prevention and intervention of adolescents' NSSI in practice.

Relationship of Social Support with Emotion Regulation and NSSI

The results showed a significant correlation between social support and adolescent NSSI behavior ($\beta=0.198, P<0.001$), assuming that H8 holds. Second, positive emotion regulation had a positive correlation with social support ($\beta=1.155, P<0.001$), and negative emotion regulation had a negative correlation with social support ($\beta=-0.931, P<0.001$). It

illustrates the impact of social support on emotion regulation, assuming that H9 is true. Further analysis of the intermediary relationship between social support in emotion regulation and adolescent NSSI behavior found that social support in negative emotion regulation ($\beta=-0.184$, $P<0.001$), positive emotion regulation ($\beta=0.229$, $P<0.001$), and NSSI, has significant mediating effects, indicating that sleep mediates between emotion regulation and adolescent NSSI behavior, which supports the view of Christoffersen et al.⁴⁹ However, verifying the independent variables of social support, negative emotion regulation ($\beta=-0.063$, $P>0.05$), and positive emotion regulation ($\beta=-0.060$, $P>0.05$) indicated that social support has no regulatory effect on emotion regulation and adolescent NSSI behavior. Therefore, the hypothesis H10 is partially true. Thus, the relationship between social support in different ways of emotion regulation and NSSI behavior is still unclear, and a higher amount of in-depth discussion is needed to find a highly authentic relationship.

Conclusion

There is a significant correlation between emotion regulation and NSSI behavior in adolescents. Negative emotion regulation is negatively correlated with NSSI behavior, while positive emotion regulation is positively correlated with NSSI behavior. The direct effect of negative emotion regulation on adolescent NSSI behavior is regulated by sleep, and high sleep quality can effectively alleviate the negative effect of negative emotion regulation on NSSI behavior. The direct effect of positive emotion regulation on adolescents' NSSI behavior is regulated by exercise, and exercise can effectively promote the effect of positive emotion regulation on adolescents' NSSI behavior. Therefore, for middle schools in China, especially those in underdeveloped rural areas, in the absence of systematic guidance on NSSI crisis intervention strategies, appropriate intervention on adolescents' sleep state and exercise levels may serve to resolve their emotional state and NSSI behavior.

Data Sharing Statement

The data used to support the findings of this study are available from the corresponding author upon request.

Ethics Statement

This study was conducted in accordance with the Declaration of Helsinki, and it has been approved by the Human Research Ethics Committee of Sultan Idris University of Education (No. 2022-0465-01).

Author Contributions

Dr.Pau and Dr. Hapsah focus on the conception and design of the study; Dr. Lan and Mrs. Huang focus on the acquisition of data, and drafting the article or revising it critically for important intellectual content; Dr. Lan focus on the analysis and interpretation of data.

Funding

Supported by Basic Ability Improvement Project of Young and Middle-aged Teachers in Universities of the Education Department of Guangxi Zhuang Autonomous Region, China (No.2021KY0604).

Disclosure

The authors report no conflicts of interest in this work.

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