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The roles of negative mood, impulsivity, and executive dysfunction in non-suicidal self-injury behaviors among Chinese middle school students

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Abstract

Background Previous studies have identified negative mood, impulsivity, and executive dysfunction as potential risk factors for non-suicidal self-injury (NSSI) in adolescents. However, the interplay of these factors and their gender-specific effects on NSSI remain unclear.

Methods In 2023, a sample of 1084 middle school students (M_{age} = 13.33; N_{boy}=574, N_{girl}=510) completed psychological assessments measuring negative mood, impulsivity, executive dysfunction, and NSSI thoughts and behaviors over the past year.

Results (1) All variables were significantly correlated (all *p values* < 0.05); (2) Negative mood ($\beta = 0.007$, $p = 0.002$ for boys; $\beta = 0.408$, $p < 0.001$ for girls) and executive dysfunction ($\beta = 0.209$, $p < 0.001$ for boys; $\beta = 0.124$, $p = 0.041$ for girls) significantly predicted NSSI thoughts in both genders, whereas impulsivity showed no predictive effect; (3) Gender differences emerged in NSSI behaviors: negative mood ($\beta = 0.395$, $p < 0.001$) and impulsivity ($\beta = 0.132$, $p = 0.005$) were significant predictors among girls, whereas executive dysfunction ($\beta = 0.200$, $p < 0.001$) was a strong predictor among boys; (4) Impulsivity moderated the association between NSSI thoughts and NSSI behaviors in girls ($\beta = 0.562$, $p < 0.001$), but not in boys (β = -0.079, $p = 0.390$).

Conclusion The influencing factors of NSSI behaviors exhibit notable gender differences. Tailored interventions should prioritize negative mood and impulsivity in girls, while addressing executive dysfunction in boys. Additionally, girls with high impulsivity and NSSI thoughts warrant closer monitoring, as they may be at a greater risk of engaging in NSSI behaviors.

Keywords Non-suicidal self-injury, Negative mood, Impulsivity, Executive dysfunction, Gender differences

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Introduction

Non-suicidal self-injury (NSSI) refers to a variety of direct and intentional behaviors that individuals damage their body tissues without fatal suicide intention [1]. Adolescence is a susceptible stage for NSSI. Research found that the prevalence of NSSI steadily increased from age 12, peaked between ages 14 and 16, and began to decline around age 18 [2]. According to the finding of a recent meta-analysis, the global lifetime prevalence of NSSI in non-clinical sample of adolescents from 2010 to 2021 was 22.0% [3] and the lifetime prevalence rate of NSSI among Chinese adolescents was 24.7% [4]. There were also gender differences in the prevalence of NSSI among adolescents, with females approximately 1.5 times more likely than males to report NSSI engagement [5]. Researchers highlighted that an early onset of NSSI may indicate more serious physical and mental diseases [6]. In addition, NSSI was a strong predictor of future risky behaviors (e.g., suicide) in adolescents, girls with NSSI should be paid more attention because of the higher risk of suicide and repeated NSSI [7]. In view of the high incidence and risk of adolescent NSSI, it is vital to explore the influencing factors of adolescent NSSI and the gender difference. According to related models (e.g., the experiential avoidance model, the stress-sensitization model, the dual-system model), negative mood, impulsivity, and executive dysfunction may be potential influencing factors for NSSI in adolescents [8–10].

The experiential avoidance model (EAM) provides a theoretical framework for understanding the occurrence and maintenance of NSSI. Within the EAM framework, NSSI is conceptualized as a maladaptive avoidance and escape behavior [8]. When individuals experience negative mood, they develop an urge to escape from aversive emotional arousal, leading them to engage in NSSI as a means of immediate relief. This behavior subsequently reduces or eliminates distressing emotion states, thereby negatively reinforcing the NSSI behavior. Over time, repeated cycles of negative reinforcement strengthen the association between negative mood and NSSI, ultimately establishing it as an automatic escape response [8, 11]. Previous research consistently indicates that adolescents often experience negative mood states prior to engaging in NSSI, with the intent of alleviating these emotions [12, 13]. A meta-analysis further supports this association, revealing that individuals with anxiety disorders and depression are at significantly higher risk for NSSI compared to those without such emotional disorders [14]. Additionally, studies on adolescents highlight gender differences, with girls reporting higher levels of negative mood and exhibiting stronger emotional reactions to stress than boys [15–17]. These findings align with clinical research demonstrating that adolescent girls are approximately twice as likely as boys to experience depression and anxiety disorders [18]. The disparity in negative mood levels between adolescent boys and girls may stem from their distinct emotion regulation strategies [5]. Notably, females tend to rely more on NSSI than males as a means of alleviating negative mood [18].

The stress-sensitization model posits that impulsivity serves as a key personality-based susceptibility factor for NSSI [9]. Defined as a trait characterized by a deficient planning, low task persistence, and a propensity for rash actions during negative affective states [19], impulsivity has been theoretically linked to NSSI vulnerability. Impulsive individuals may be particularly prone to NSSI due to the behavior's typically unplanned and immediate nature [20]. Emprical support for this association comes from a meta-analysis demonstrating that distinct impulsivity facets including mood-based impulsivity, cognitive impulsivity, and behavioral impulsivity confer unique risks across the NSSI trajectory [21]. Existing research has consistently shown robust associations between traits impulsivity and NSSI [22], with longitudinal evidence suggesting impulsivity may predict NSSI onset [23]. Neurocognitive studies further indicate that impulsivity in negative mood states correlates with more frequent and recent NSSI episodes [24, 25]. Most of the aforementioned findings were derived from adult sample. However, adolescents may be particularly susceptible to impulsivity, as neural circuits associated with emotional regulation and inhibitory undergo prolonged maturation [26]. Given this developmental vulnerability, further investigation is warranted to elucidate the interaction between impulsivity and negative mood in adolescent NSSI. Additionally, prior research has reported mixed findings regarding gender differences in impulsivity. Some studies, such as those using the Barratt Impulsiveness Scale-11, suggest that adolescent girls exhibit higher impulsivity than boys [27], whereas others reported comparable levels [28, 29] or no significant gender differences [30]. Notably, highly impulsive girls may be at greater risk of internalizing problems, which in turn could predispose them to NSSI [31, 32].

The dual-system model proposes that adolescent behavioral problems (e.g., substance addiction, NSSI, etc.) stem from an imbalance between two neurophysiological systems [10]: the subcortical socioemotional system, which is responsible for responses to emotional stimuli, novelty, and rewards; and the cognitive control system of the prefrontal cortex, which governs impulse regulation [33], emotion management, and decision making [34]. Executive function, heavily reliant on prefrontal activation [35], plays a critical role in behavioral regulation. Emerging evidence suggests that executive dysfunction may serve as an endophenotype for early NSSI identification [36]. Neuroimaging studies further indicate that NSSI is associated with deficits in neural

substrates of emotional processing and executive control [37, 38]. Specifically, Individuals with NSSI exhibited abnormal activation in frontal regions, including the prefrontal cortex (PFC), anterior cingulate cortex (ACC), and orbitofrontal cortex (OFC) [39]. Clinical comparisons reveal that NSSI patients demonstrated reduced activation in the dorsolateral prefrontal cortex (DLPFC) relative to healthy controls [40], correlating with more pronounced executive dysfunction. In addition, gender differences have been observed in key neurotransmitter systems and neural activation patterns within executive function-related regions (e.g., PFC, striatum) [41]. Females, for instance, exhibit greater DLPFC and right parietal cortex activation compared to males [42], suggesting potential sex-specific neurocognitive mechanism in behavioral regulation.

Previous researches have identified negative mood, impulsivity, and executive dysfunction as potential risk factors for NSSI in adolescents [13, 21, 36], however, the interplay of these factors and their gender-specific effects on NSSI remain unclear. Impulsive individuals, for instance, are more susceptible to negative mood and may resort to NSSI as a maladaptive coping mechanism to alleviate distress and regulate emotions [43]. Furthermore, negative mood frequently co-occurs with executive dysfunction and NSSI [44], as heighten negative mood can impair executive functioning [40, 44]. This may occur because negative mood consumes substantial attentional resources, diminishing available executive capacity and hindering effortful task processing [45], thereby increasing vulnerability to risky behaviors such as NSSI.

Notably, NSSI thoughts are significantly more prevalent than actual NSSI behaviors among adolescents, with approximately 20% reporting NSSI thoughts compared to only 5% engaging in NSSI behaviors within the past month [46]. While prior research has examined the predictors of NSSI thoughts and NSSI behaviors independently, few studies have investigated the factors driving the transition of ideation to action in adolescents. According to the integrated motivational-volitional model (IMV), this progression might be particularly pronounced among individuals with high impulsivity [47, 48], suggesting a critical role of impulse control in the escalation of NSSI.

Therefore, this study first constructed hierarchical regression models within the overall sample of middle school students to examine potential gender differences in the predictive roles of negative mood, impulsivity, and executive dysfunction in relation to NSSI thoughts and behaviors. Subsequently, among boys and girls with NSSI thoughts, we investigated impulsivity as the moderator to further explore gender-specific differences in how impulsivity influences the relationship between NSSI thoughts and behaviors (see Fig. 1).

Methods

Participants and procedure

This study used cluster sampling method to select 1200 adolescents from a middle school in Hunan Province in September 2023. Prior to questionnaire administration in class, researchers provided students with a detailed informed consent form, explaining the purpose of the study, confidentiality of privacy issues, voluntary participation, and the right to withdraw at any time. Written consent was obtained from all participants and their legal guardians. After excluding invalid responses including incomplete questionnaires and careless responses, the final sample comprised 1084 valid participants (retention rate: 90.33%), aged 11–16 years (M = 13.33, SD = 0.89). The sample included 574 boys (M = 13.41, SD = 0.87) and 510 girls (M = 13.24, SD = 0.91).

Measures

Negative mood

The Chinese version of Depression, Anxiety Stress Scale (DASS-21) was used to assess negative mood and had

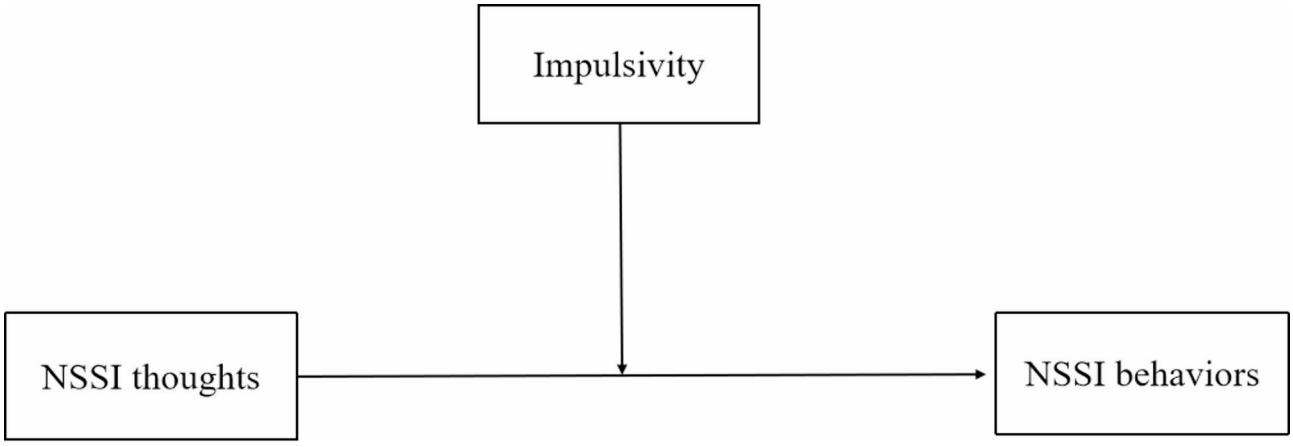

Fig. 1 The hypothesis model diagram of moderating effect

good reliability and validity among Chinese adolescents [49]. DASS-21 consists of 3 subscales with a total of 21 items, and all items are scored on a 4-Likert scale (0–3). The total score is the sum of the scores for each subscale. Higher scores indicate a higher level of negative mood. The Cronbach's alpha of DASS total was 0.932 in the present sample.

Impulsivity

The Chinese version of Barratt Impulsive Scale-Brief (BBIS) was used to assess impulsivity and had good reliability and validity among Chinese adolescents [50]. The BBIS has 8 items, including two dimensions: poor self-regulation and impulsive behavior, and all items are scored on a 4-Likert scale (1–4). Items 1, 4, 5, and 6 are reverse-scored questions. Higher scores indicate higher impulsivity. The Cronbach's alpha of BBIS total was 0.708 in the present sample.

Executive dysfunction

The Chinese version of Dysexecutive Questionnaire (DEX) [51] was used to assess executive dysfunction, with a total of 20 items. All items are scored on a 5-Likert scale (0–4). The total score ranges from 0 to 80, with higher scores indicating more severe executive dysfunction. The Chinese version of DEX had good reliability and validity [51, 52]. The Cronbach's alpha was 0.937 in the present sample.

NSSI thoughts and behaviors

The Chinese version of Ottawa Self-injury Inventory (OSI) [53] was used to assess the frequency of NSSI thoughts and behaviors in the past year rated on a four-point scale (0 = never, 1 = 1–5 times, 2 = once a month, 3 = once a week, 4 = every day). Response "0" indicates no history of NSSI thoughts or NSSI behaviors in the past year; response"1–4" indicates a history of NSSI thoughts or NSSI behaviors in the past year. This scale had good reliability and validity in samples of Chinese adolescents [53, 54], and previous study has also used this method to assess NSSI [55].

Table 1 Gender differences in negative mood, impulsivity, executive dysfunction, and NSSI thoughts and behaviors (N_{boy} = 574, N_{girl} = 510)

Variables		Boy	Girl	t/χ^2	*p*
Negative mood		23.59 ± 21.55	28.07 ± 23.11	-3.298	0.001
Impulsivity		18.37 ± 4.11	19.01 ± 4.20	-2.543	0.011
Executive dysfunction		17.94 ± 14.46	20.99 ± 15.52	-3.344	0.001
NSSI thoughts	No	464(80.84%)	344(67.45%)	25.494	< 0.001
	Yes	110(19.16%)	166(32.55%)		
NSSI behaviors	No	513(89.37%)	430(84.31%)	6.108	0.013
	Yes	61(10.63%)	80(15.69%)		

Data analysis

Data analysis was performed in SPSS27 and Mplus8. Prior to analysis, missing value were examined, revealing that the proportion of missing data did not exceed 10%, thus, cases with missing data were directly excluded. To assess common method bias, we employed Harman's single factor test and confirmatory factor analysis (CFA). Independent sample t-test and chi-square test were utilized to examine gender differences across study variables. Pearson correlation analysis was performed to analyze the correlations between variables. To identify potential predictors of NSSI thoughts and behaviors, we conducted hierarchical regression analysis separately in boys and girls. Finally, the moderating effect analysis based on hierarchical regression results was conducted respectively for boys and girls with NSSI thoughts using the PROCES model in SPSS.

Results

Common method Bias

First, unrotated exploratory factor analysis (EFA) was performed using the Harman's single factor test on all measurement items. The results revealed 8 factors with characteristic roots greater than 1, with the first common factor accounting for 33.308% of the variance (below the critical threshold of 40%). Additionally, confirmatory factor analysis (CFA) was conducted by loading all scale items onto a single factor to further examine common method bias. The model demonstrated poor fit indices (χ^2/df = 5.593, *RMSEA* = 0.065, *CFI* = 0.700, *TLI* = 0.688, *SRMR* = 0.071), suggesting that a single-factor structure was inadequate. Based on these analyses, the finding indicated that common method bias did not significantly affect the research data.

Descriptive statistics

Gender differences in negative mood, impulsivity, executive dysfunction, NSSI thoughts and NSSI behaviors

Independent sample t-test and chi-square test showed that boys have lower levels of negative mood (t = -3.298, p = 0.001), impulsivity (t = -2.543, p = 0.011), executive dysfunction (t = -3.344, p = 0.001), NSSI thoughts (χ^2 = 25.494, p < 0.001) and behaviors (χ^2 = 6.108, p = 0.013) than girls, see Table 1.

Correlation analysis between variables

Among both boys and girls, negative mood, impulsivity, executive dysfunction, NSSI thoughts, and NSSI behaviors demonstrated significant positive intercorrelations (all *p values* < 0.05), see Supplemental Table 1.

Table 2 Hierarchical regression analysis for NSSI thoughts and behaviors among boys (N_{boy} = 574)

Model	Regression equation		Overall fit index			Significance of regression coefficients				
		Predictor variable	R	R^2	F	β	LLCI	ULCI	t	*p*
Model 1	NSSI thoughts	Negative mood	0.329	0.108	69.406***	0.329	0.009	0.015	8.331	< 0.001
Model 2		Negative mood	0.339	0.115	36.979***	0.293	0.008	0.014	6.800	< 0.001
		Impulsivity				0.088	0.001	0.033	2.042	0.042
Model 3		Negative mood	0.371	0.137	30.286***	0.166	0.002	0.010	3.083	0.002
		Impulsivity				0.053	-0.006	0.027	1.222	0.222
		Executive dysfunction				0.209	0.006	0.017	3.883	< 0.001
Model 1	NSSI behaviors	Negative mood	0.230	0.053	31.922***	0.230	0.005	0.009	5.650	< 0.001
Model 2		Negative mood	0.230	0.053	15.936***	0.229	0.004	0.010	5.125	< 0.001
		Impulsivity				0.003	-0.013	0.014	0.077	0.939
Model 3		Negative mood	0.271	0.074	15.091***	0.107	0.000	0.007	1.923	0.055
		Impulsivity				-0.030	-0.019	0.009	-0.66	0.509
		Executive dysfunction				0.200	0.004	0.014	3.570	< 0.001

Notes: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. LLCI represents the lower level of the confidence interval, and ULCI represents the upper level of the confidence interval

Table 3 Hierarchical regression analysis for NSSI thoughts and behaviors among girls (N_{girl} = 510)

Model	Regression equation		Overall fit index			Significance of regression coefficients				
		Predictor variable	R	R^2	F	β	LLCI	ULCI	t	*p*
Model 1	NSSI thoughts	Negative mood	0.546	0.298	215.281***	0.546	0.018	0.024	14.672	< 0.001
Model 2		Negative mood	0.555	0.308	112.69***	0.491	0.016	0.022	11.660	< 0.001
		Impulsivity				0.114	0.007	0.042	2.718	0.007
Model 3		Negative mood	0.560	0.313	76.995***	0.408	0.011	0.02	7.021	< 0.001
		Impulsivity				0.086	0.000	0.037	1.959	0.051
		Executive dysfunction				0.124	0.000	0.014	2.047	0.041
Model 1	NSSI behaviors	Negative mood	0.470	0.221	144.126***	0.470	0.000	0.012	12.005	< 0.001
Model 2		Negative mood	0.485	0.235	77.948***	0.405	0.000	0.010	9.159	< 0.001
		Impulsivity				0.136	0.002	0.008	3.064	0.002
Model 3		Negative mood	0.485	0.235	51.890***	0.395	0.008	0.016	6.428	< 0.001
		Impulsivity				0.132	0.007	0.037	2.833	0.005
		Executive dysfunction				0.016	-0.005	0.006	0.251	0.802

Notes: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. LLCI represents the lower level of the confidence interval, and ULCI represents the upper level of the confidence interval

Gender differences in hierarchical regression analysis of psychological factors predicting NSSI

In the hierarchical regression model, see Tables 2 and 3, Model 1 included negative mood as an independent variable. The results showed that for both boys and girls, negative mood positively predicted NSSI thoughts (boys: $\beta = 0.329$, $p < 0.001$; girls: $\beta = 0.546$, $p < 0.001$) and NSSI behaviors (boys: $\beta = 0.230$, $p < 0.001$; girls: $\beta = 0.470$, $p < 0.001$).

In Model 2, impulsivity was added as independent variable based on Model 1. Among boys, negative mood positively predicted NSSI thoughts ($\beta = 0.293$, $p < 0.001$) and NSSI behaviors ($\beta = 0.229$, $p < 0.001$); impulsivity positively predicted NSSI thoughts ($\beta = 0.088$, $p = 0.042$), but did not predict NSSI behaviors ($\beta = 0.003$, $p = 0.939$). Among girls, negative mood positively predicted NSSI thoughts ($\beta = 0.491$, $p < 0.001$) and NSSI behaviors ($\beta = 0.405$, $p < 0.001$); impulsivity positively predicted NSSI thoughts ($\beta = 0.114$, $p = 0.007$) and NSSI behaviors ($\beta = 0.136$, $p = 0.002$).

Model 3 was based on Model 2 and added executive dysfunction as an independent variable. For boys, negative mood positively predicted NSSI thoughts ($\beta = 0.007$, $p = 0.002$), but did not predict NSSI behaviors ($\beta = 0.107$, $p = 0.055$); impulsivity did not predict NSSI thoughts ($\beta = 0.053$, $p = 0.222$) and NSSI behaviors (β = -0.030, $p = 0.509$); executive dysfunction positively predicted NSSI thoughts ($\beta = 0.209$, $p < 0.001$) and NSSI behaviors ($\beta = 0.200$, $p < 0.001$). For girls, negative mood positively predicted NSSI thoughts ($\beta = 0.408$, $p < 0.001$) and NSSI behaviors ($\beta = 0.395$, $p < 0.001$); impulsivity did not predict NSSI thoughts ($\beta = 0.086$, $p = 0.051$), but impulsivity positively predicted NSSI behaviors ($\beta = 0.132$, $p = 0.005$); executive dysfunction positively predicted NSSI thoughts ($\beta = 0.124$, $p = 0.041$), but did not predict NSSI behaviors ($\beta = 0.016$, $p = 0.802$).

Table 4 The moderation analysis of impulsivity among boys and girls with NSSI thoughts (N_{boy} = 110, N_{girl} = 166)

Gender	Regression equation		Overall fit index			Significance of regression coefficients				
		Predictor variable	R	R^2	F	β	LLCI	ULCI	t	*P*
Boy	NSSI behaviors	NSSI thoughts	0.618	0.382	21.866***	0.960	0.722	1.198	8.003	< 0.001
		Impulsivity				-0.189	-0.462	0.084	-1.375	0.172
		NSSI thoughts × Impulsivity				-0.079	-0.261	0.103	-0.863	0.390
Girl	NSSI behaviors	NSSI thoughts	0.709	0.502	54.490***	0.626	0.448	0.804	6.938	< 0.001
		Impulsivity				0.391	0.209	0.573	4.236	< 0.001
		NSSI thoughts × Impulsivity				0.562	0.376	0.748	5.964	< 0.001

Notes: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. LLCI represents the lower level of the confidence interval, and ULCI represents the upper level of the confidence interval

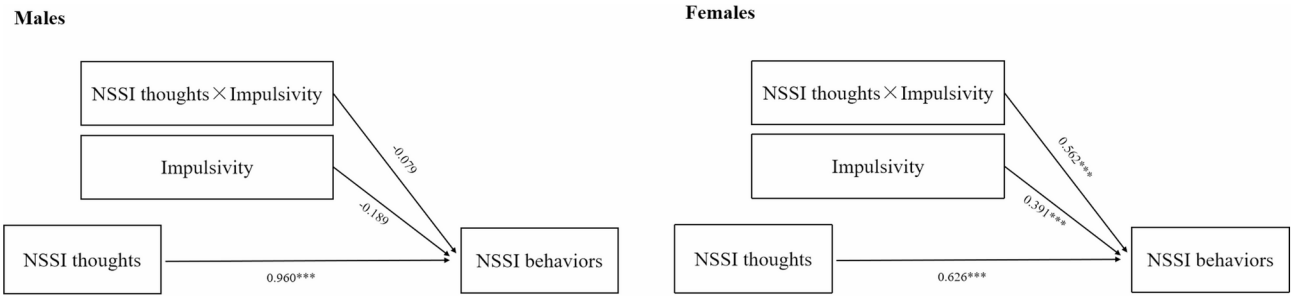

Fig. 2 The moderating effect models among boys and girls with NSSI thoughts (N_{boy} = 110, N_{girl} = 166)

The moderation analysis of impulsivity on the relationship between NSSI thoughts and NSSI behaviors

Differences between the NSSI thoughts-Only group and the NSSI thoughts with behaviors group

Among both boys and girls, the NSSI Thoughts with Behaviors group exhibited significant higher levels of negative mood (boys: t = -2.749, p = 0.007; girls: t = -3.903, p < 0.001) and executive dysfunction (boys: t = -3.339, p = 0.001; girls: t = -2.808, p = 0.006) compared to the NSSI Thoughts-Only group. However, the difference in impulsivity between the two groups was statistically significant only for the girls (t = -2.915, p = 0.004) but not the boys (t = -0.382, p = 0.703), see Supplemental Table 2.

Gender differences in the moderating effect of impulsivity

Hierarchical regression indicated that impulsivity didn't predict NSSI thoughts both in boys and girls, but impulsivity predicted NSSI behaviors only in girls. Thus, our study incorporated impulsivity as a moderator to explore how impulsivity affects the relationship between NSSI thoughts and behaviors. The study standardized all variables and constructed a moderated effects model using Model1 (Bootstrap sampling of 5000) in the PROCESS macro program.

The moderating effect of NSSI thoughts on NSSI behaviors was tested separately in boys and girls, see Table 4; Fig. 2. The interaction term between NSSI thoughts and impulsivity significantly predicted NSSI behaviors only in girls (β = 0.562, p < 0.001) but not boys (β = -0.079, p = 0.390) with NSSI thoughts. The results showed that impulsivity moderated the relationship between NSSI thoughts and NSSI behaviors in girls, but not in boys.

In order to reveal the interaction between NSSI thoughts and impulsivity among girls, a simple slope analysis was performed by adding or subtracting one standard deviation from the mean impulsivity score into high and low impulsivity groups. NSSI thoughts did not predict NSSI behaviors in the low impulsivity condition (*effect* = 0.072, p = 0.630), see Fig. 3. However, NSSI thoughts positively predicted NSSI behaviors in the high impulsivity condition (*effect* = 1.180, p < 0.001). The results showed that as the level of impulsivity increased, the predictive effect of NSSI thoughts on NSSI behaviors increased.

Discussion

This study sought to explore the potential factors influencing NSSI thoughts and behaviors, as well as the progression from NSSI thoughts to NSSI behaviors among Chinese middle school students. Results revealed that, while no gender differences were observed in predicting NSSI thoughts, distinct gender-based patterns emerged in predicting NSSI behaviors. Among girls, negative mood and impulsivity were significantly predictors of NSSI behaviors, whereas among boys, executive dysfunction played a more prominent role in predicting NSSI behaviors. Furthermore, impulsivity moderated the association between NSSI thoughts and NSSI behaviors in girls, but this effect was not observed in boys.

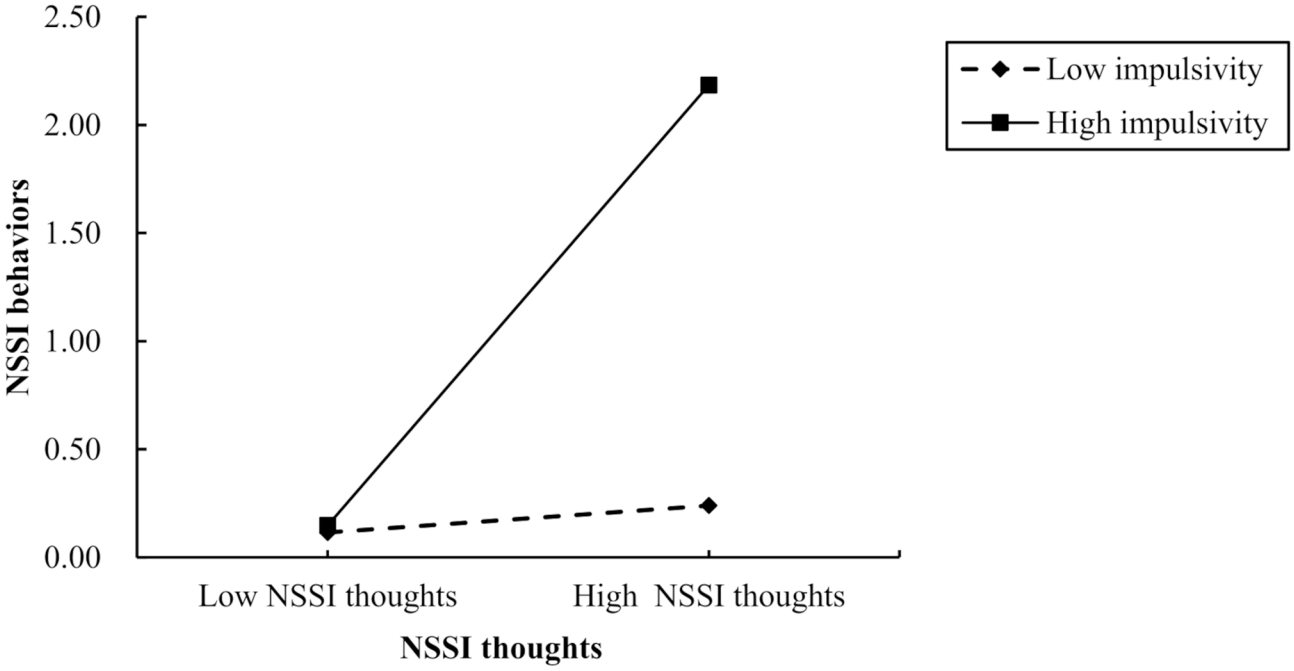

Fig. 3 The moderating effect of impulsivity between NSSI thoughts and behaviors among girls with NSSI thoughts (N_{girl} = 166)

Gender differences in the prevalence of NSSI thoughts and behaviors in the past year among middle school students

Our results revealed significant gender differences in the prevalence of NSSI thoughts (32.55% vs. 19.16%) and behaviors (15.69% vs. 10.63%) among middle school students, with girls exhibiting higher rates than boys. These results align with prior studies [5, 56], which have consistently identified female gender as an independent predictor of NSSI [57]. Notably, gender disparities in NSSI prevalence tend to be more pronounced in clinical populations [5], possibly due to gendered differences in treatment-seeking behaviors. Males may face greater stigma when seeking mental health treatment [58, 59], while females are more likely to recognize NSSI as a problem requiring intervention [60]. However, gender differences in NSSI prevalence were not a static and may vary across developmental stages. Research indicates that while NSSI is more prevalent among females aged 16–19, no significant gender differences are observed at younger/older ages [56]. Biological factors such as hormonal variations (e.g., testosterone vs. estradiol), may contributed to these differences [5].

Additionally, the likelihood of adolescents' susceptibility to NSSI under negative emotional states appear to differ by gender. Some evidence suggests that heightened negative mood (e.g., depression, anxiety, and stress) in girls partially accounts for their increased risk of NSSI during adolescence [56]. Psychological and personality factors may further explain these gender disparities [61]. Impulsivity, neuroticism, and low responsibility have been implicated in NSSI [62, 63], with females generally exhibiting higher impulsivity than males. Similarly, traits associated with Borderline Personality Disorder (BPD) traits such as emotional instability, mood dysregulation, and interpersonal difficulties may elevate NSSI risk [61]. Girls also report slightly higher BPD symptoms than boys, potentially contributing to the observed gender difference in NSSI engagement.

Predictors of NSSI thoughts and behaviors among middle school students: gender-specific influences

NSSI thoughts and behaviors represent distinct yet interrelated phenomena, as not all thoughts lead to behaviors, and not all behaviors are preceded by explicit thoughts [64, 65]. Our finding highlighted that the factors influencing NSSI thoughts and behaviors vary by gender. Notably, negative mood and executive dysfunction significantly predicted NSSI thoughts in both boys and girls, whereas impulsivity did not emerge as a significant predictor. This suggests a lack of gender differences in the cognitive and affective precursors of NSSI thoughts.

Adolescence is a developmental period marked by psychosocial immaturity and heightened emotional reactivity [66], which may increase vulnerability to NSSI thoughts under conditions of depression and anxiety [46]. Furthermore, the prefrontal cortex, crucial for executive functioning, shows pronounced maturational changes during adolescence [67], making it particular susceptible to environmental influences [68]. Adolescents with executive dysfunction struggle to regulate emotional information, impairing adaptive coping and elevating the risk of NSSI thoughts compared to their peers [36, 69]. Contrary

to expectations, impulsivity did not significantly predict NSSI thoughts after controlling for negative mood and executive dysfunction in either gender. This finding may reflect methodological limitation in assessing impulsivity. Our study relied on self-reported measures, which may bias adolescents towards evaluating behaviors (e.g., "I act without thinking") rather than cognitive (e.g., "I have intrusive urges") aspects of impulsivity. For instance, individuals might retrospectively attribute impulsivity to overt actions like self-harm rather internal thought processes [22]. Future research should incorporate multimethod assessments, including both self-reported trait impulsivity and objective behavioral tasks, to better capture its role in NSSI.

Regarding influencing factors of NSSI behaviors in middle school students, firstly, our findings align with the experiential avoidance model [8], demonstrating that negative mood (e.g., depression, anxiety, stress) significantly predicted NSSI behaviors in girls but not in boys. This gender disparity may be attributed to several key factors. Girls report higher level of negative mood compared to boys, with this difference being most pronounced during mid-adolescence [70]. This emotion vulnerability likely contributes to the elevated incidence of NSSI behaviors among girls [18, 56]. Earlier pubertal development in girls [71] may lead to heightened emotional reactivity to life stressors during early adolescence [72], increasing their susceptibility to using NSSI as a maladaptive coping mechanism for distress [18, 57]. Notably, girls are more likely to than boys to endorse emotion regulation as a primary function of NSSI [61], suggesting that greater emotion dysregulation may underlie their increased risk. However, this gender difference appears developmentally specific, while adolescent girls show an inverted U-shaped trajectory of NSSI (rising in early adolescence, peaking at 16–17 years, then declining) [56], adolescent boys exhibit relatively stable rates across age. Intriguingly, the predictive effect of depression/anxiety on NSSI shows no gender differences in adult populations (age 18+) [73], highlighting adolescence as a critical period for gendered manifestations of NSSI behaviors.

Secondly, consistent with the dual-system model [10], executive dysfunction significantly predicted NSSI behaviors in boys but not in girls. This finding indicated that NSSI behaviors were more likely to co-occur with executive dysfunction in boys, highlighting potential gender-specific cognitive mechanism underlying NSSI. The observed association in boys may be attributable to the ongoing development of the prefrontal cortex during early adolescence, which is linked to poor emotion regulation [74]. Given documented gender differences in prefrontal cortex maturation during this developmental period [75], executive function may differentially influence NSSI behaviors across sexes. Prior research supports this notion, demonstrating gender disparities in executive function development among adolescents [76, 77]. For instance, a cross-sectional study ($n = 649$, aged 8–30) revealed distinct developmental trajectories in neuropsychological functions across gender, with males exhibiting comparatively weaker performance [75]. Similarly, previous research found that adolescents with high-severity NSSI behaviors, particularly boys, often displayed deficits in spatial working memory [45]. In contrast, our study found that executive dysfunction did not significantly predict NSSI behaviors in girls after controlling for negative mood and impulsivity. Consistently, a prior study reported no significant differences in executive function (i.e., the Stroop Test and the Card Sorting Test) between girls with and without NSSI behaviors [78]. However, it is important to note that our assessment of executive dysfunction relied on self-reported measure. Further studies should incorporate objective executive function tasks to further validate these gender differences in the relationship between executive dysfunction and NSSI behaviors.

Lastly, consistent with the stress-sensitization model [9], impulsivity predicted NSSI behaviors in girls but not in boys. According to prior research, impulsivity may heighten vulnerability to maladaptive coping strategies, such as NSSI, as a means of regulating negative affective states [79]. Indeed, impulsivity has been identified as a key factor in explaining NSSI among females [80]. For instance, negative urgency, a dimension of the UPPS-P model, significantly predicted NSSI behaviors in girls over 9-month follow-up period later [23]. Furthermore, impulsivity has been shown to differentiate NSSI adolescents from healthy controls among girls (but not boys) [81]. Clinical studies further support this gender disparity, indicating that the association with impulsivity and NSSI behaviors is weaker in boys than in girls [61].

In the present study, impulsivity did not significantly predict NSSI behaviors among boys after controlling for negative mood and executive dysfunction. This finding aligns with previous work suggesting that boys reported fewer NSSI urges and may employ a broader range of maladaptive coping strategies, thereby reducing the salience of NSSI as a response to negative mood [61]. However, contrasting evidence exists, one study of adults found no gender differences in the relationship between impulsivity on NSSI behaviors, with both females and males equally likely to engage in such behaviors [73]. This discrepancy may stem from developmental difference, as adults, who tend to exhibit greater emotional and behavioral maturity, may demonstrate lower impulsivity compared to adolescents, who are prone to impulsive thoughts and behaviors during this critical period of physical and psychological development. In conclusion, our finding indicate that impulsivity directly predicted

NSSI behaviors (but not NSSI thoughts) specifically among girls. These results underscore the importance of targeted intervention for highly impulsive girls, who may be at elevated risk for engaging in NSSI behaviors.

Gender differences in the transition from NSSI thoughts to NSSI behaviors among middle school students

This study revealed that 25.5% of middle school students reported experiencing NSSI thoughts in the past year, while 13.0% engaged in actual NSSI behaviors. This suggests that only approximately half of the students with NSSI thoughts ultimately transitioned to NSSI behaviors, consistent with prior research indicating NSSI thoughts do not invariably lead to action [64, 82]. Many individuals with NSSI thoughts actively resist the urge to engage in NSSI behaviors, employing alternative coping strategies instead [64].

Notably, gender differences emerged in the factors influencing this transition. Among girls with NSSI thoughts, impulsivity significantly moderated of the relationship between NSSI thoughts on NSSI behaviors, with higher impulsivity levels strengthening this association. This finding align with the integrated motivational-volitional model [47, 83], which posits that impulsivity plays a critical role in the volitional phase, distinguishing between those who merely contemplate NSSI and those who proceed to act [84]. Impulsive has been identified as a key moderator in the volitional pathway [48, 83], as individuals with poor self-control may act impulsively on transient NSSI thoughts, rapidly translating them into concrete behaviors [85]. Thus, while high impulsivity exacerbates the risk of transitioning from NSSI thoughts to behaviors, low impulsivity may serve as a protective factor, reducing the likelihood of behavioral engagement. In contrast, among boys with NSSI thoughts, impulsivity did not significantly moderate this relationship. This discrepancy may stem from gender-specific coping mechanism; boys with NSSI thoughts may be more inclined to adopt alternative strategies, such as substance addiction or violent behavior [61], rather than resorting to NSSI behaviors.

Limitations and future directions

This study has several limitations that should be acknowledged. First, due to its cross-sectional design, the findings do not permit causal inferences between variables, nor do they capture the temporal dynamics of each variable. Future research should employ longitudinal designs to examine the dynamic relationships among these constructs over time. Second, the generalizability of the results may be limited, as the sample was draw from a single middle school. To enhance external validity, subsequent studies should incorporate more diverse and representative samples. Finally, while this study focused on risk factors (e.g., negative mood, impulsivity, executive dysfunction) in predicting NSSI, future investigations should also integrate protective factors (e.g., resilience, school connectedness, family adaptability and cohesion, social support) into the analytical framework. Such an approach would provide a more comprehensive understanding of the mechanisms underlying gender differences in NSSI.

Despite these limitations, our study offers valuable theoretical and practical insights. By employing hierarchical regression analysis, we identified key factors influencing non-suicidal self-injury (NSSI) and examined gender differences, thereby deepening the understanding of NSSI mechanisms and providing empirical support for gender-specific variations in adolescent NSSI. Furthermore, our findings contribute to the validation of prominent NSSI theoretical frameworks, including the experiential avoidance model, the dual-system model, and the stress-sensitization model, while also shedding light on potential mechanisms underlying gender differences in NSSI. From a clinical perspective, this study underscores the importance of targeted interventions for adolescents at risk of NSSI. Specifically, greater attention should be given to adolescent girls exhibiting NSSI ideation and high impulsivity during clinical assessments and intervention planning. Psychotherapeutic approaches such as Dialectical Behavior Therapy (DBT) [86] and mindfulness-based training [87] may be particularly effective, as both have demonstrated efficacy in reducing NSSI-related thoughts and impulsive behaviors. DBT has been shown to mitigate the intensity of NSSI ideation, whereas mindfulness training may help regulate impulsive tendencies, thereby reducing associated maladaptive behaviors.

Conclusion

The present study identified gender differences in the factors influencing NSSI behaviors among Chinese middle school students. Specifically, negative mood and impulsivity were predictive of NSSI behaviors in girls, whereas executive dysfunction emerged as a key predictor in boys. Additionally, impulsivity was found to moderate the association between NSSI thoughts and behaviors in girls. These findings highlight the importance of targeted clinical interventions, particularly for adolescent girls exhibiting high impulsivity and NSSI thoughts.

Supplementary Information

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Supplementary Material 1

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Author contributions
J.G. was responsible for manuscript writing, data collection, interpretation of data and data analysis. L.S. was responsible for research conceptualization, manuscript revision, and funding acquisition. J.X. was responsible for data collection. L.H. was responsible for investigation. S.Z. was responsible for investigation. J.G. was responsible for research conceptualization, manuscript revision, funding acquisition, and project administration. All authors read and approved the final manuscript.

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Data availability
The supporting data can be accessed from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
We have complied with the APA Ethical Principles in collecting data as a quality assurance activity. This study was approved by the Ethics Committee of Shanghai Changning Mental Health Center (No.M202151). Written informed consent was obtained from all participants and their guardians.

Consent for publication
Not applicable.

Authorship and ordering
All authors agree to the authorship order and content of the manuscript.

Uniqueness of publication
The data reported in the manuscript have not been published elsewhere. This manuscript is not under review elsewhere.

Competing interests
The authors declare no competing interests.

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