

# Childhood trauma and non-suicidal self-injury among Chinese adolescents: emotional impulsiveness, internet addiction and physical activity

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## Article

**Keywords:** childhood trauma, non-suicidal self-injury, negative urgency, Internet addiction, physical activity, network analysis, adolescents

**Posted Date:** October 6th, 2026

**DOI:** <https://doi.org/10.21203/rs.3.rs-10804282/v1>

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**Additional Declarations:** No competing interests reported.

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# Abstract

Childhood trauma is associated with adolescent non-suicidal self-injury (NSSI), but the emotional and behavioral factors underlying this association and the potential role of physical activity remain unclear. This cross-sectional study examined these relationships among 1,869 Chinese adolescents. Childhood trauma, negative urgency–related emotional impulsiveness, Internet addiction, NSSI, and physical activity were assessed using validated self-report measures. Sequential mediation analysis, a separate moderation analysis, and a 12-node EBICglasso network analysis were conducted, with gender and age controlled in the regression-based models. Childhood trauma was positively associated with NSSI. Significant indirect associations were observed through emotional impulsiveness and Internet addiction, with emotional impulsiveness showing the largest indirect association. The sequential indirect association through emotional impulsiveness and Internet addiction was also significant, although its magnitude was small. Physical activity significantly moderated the association between emotional impulsiveness and NSSI ( $\beta = -0.155$ ), with a weaker positive association at higher levels of physical activity. Network analysis was used to characterize conditional and bridge associations among childhood trauma, emotional impulsiveness, Internet addiction, NSSI, and physical activity. These findings suggest that adolescent NSSI is embedded within an interconnected system of family adversity, emotion-related impulsiveness, problematic Internet use, and lifestyle factors. Given the cross-sectional design, these findings represent statistical associations and should not be interpreted as evidence of causal or temporal relationships.

## 1. Introduction

Non-suicidal self-injury (NSSI) refers to the deliberate and direct destruction of one's own body tissue without suicidal intent (Lewis and Hasking 2025; Escofet-Colet et al. 2025). NSSI is relatively common among adolescents, frequently concealed, and associated with emotional distress, psychiatric symptoms, and an elevated risk of subsequent suicidal behavior (Xie et al. 2024; Barker et al. 2026; Hadj-Youssef et al. 2026). Accordingly, research on adolescent NSSI should examine not only its direct correlates but also the emotional and behavioral factors through which distal family adversity may be statistically associated with NSSI. Identifying potentially modifiable correlates may also inform school-based screening and prevention strategies (Baldini et al. 2025a, b).

Childhood trauma is an important distal correlate of adolescent NSSI (Zhang et al. 2022; Yang et al. 2024; Li et al. 2024). It commonly includes emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect (Zhang et al. 2024; Ke et al. 2024; Delhalle et al. 2024). Previous studies have shown that childhood trauma and adverse childhood experiences are associated with higher levels of NSSI and other self-injurious or suicidal outcomes (Wang et al. 2024; He et al. 2024; Yang et al. 2025). From a developmental psychopathology perspective, childhood trauma may reflect prolonged exposure to threat, insufficient emotional responsiveness, impaired family support, and unstable caregiving environments (Lee et al. 2023; Paetzold et al. 2023; Poon et al. 2026). Such experiences may be associated with later difficulties in emotion regulation, stress coping, and behavioral control.

Nevertheless, because much of the existing evidence is observational, these relationships should be interpreted as associations rather than evidence of temporal or causal effects.

One emotional-behavioral construct that may help explain this association is negative urgency. Negative urgency refers to the tendency to act rashly or impulsively when experiencing intense negative emotions and is commonly assessed using the Negative Urgency subscale of the UPPS-P Impulsive Behavior Scale (Smith and Cyders 2016; Um et al. 2018; Johnson et al. 2020; Clay et al. 2023; Azarmehr et al. 2026). In the present study, the term emotional impulsiveness refers specifically to this negative urgency-related tendency rather than to impulsivity in a broad sense. Negative urgency was selected because NSSI frequently occurs during intense negative affect, when an adolescent's capacity to inhibit immediate behavioral responses may be reduced (Allen and Hooley 2019; Liu et al. 2022b; Eray Çamlı et al. 2026). Adolescents with higher negative urgency may therefore be more likely to engage in poorly considered behaviors when experiencing distress, anger, shame, frustration, or a perceived loss of control.

Internet addiction represents a potentially relevant behavioral correlate of childhood trauma and adolescent NSSI. In the present study, Internet addiction refers specifically to problematic Internet-use tendencies assessed using Young's Internet Addiction Test, including impaired control, excessive dependence, functional impairment, and persistent negative consequences (Ryding and Kaye 2018; Xu et al. 2021; Chadha et al. 2024). This term is used consistently throughout the manuscript. Adolescents exposed to childhood trauma may be more likely to use online activities for emotional avoidance, distraction, immediate reward, or compensatory social connection (Wang et al. 2025; Dadandı 2026; Villanueva-Blasco et al. 2026). Internet addiction has also been associated with NSSI and other mental health difficulties among adolescents (Tang et al. 2020; Guo et al. 2020; Ma et al. 2023; Abdalla et al. 2026; Fan et al. 2026). However, these findings are primarily based on observational data and do not establish a causal relationship between Internet addiction and NSSI.

Negative urgency-related emotional impulsiveness may also be associated with Internet addiction. Adolescents who tend to act rashly under negative affect may be more likely to seek rapid emotional relief through readily accessible online activities, particularly when adaptive coping strategies and offline support are limited (Kököneyi et al. 2019; Gu 2022; Li et al. 2025; Dadandı 2026). Internet addiction is also associated with poorer offline adaptation and greater emotional and behavioral difficulties (Tang et al. 2020; Hao et al. 2022; Hu et al. 2022; Orhon et al. 2023; Wang et al. 2023; Du et al. 2025; Soriano-Molina et al. 2025). On this basis, emotional impulsiveness and Internet addiction may form a theoretically informed sequential indirect association between childhood trauma and NSSI. Nevertheless, this sequence represents a statistical model derived from cross-sectional data and should not be interpreted as evidence of temporal progression or causality.

Physical activity may represent a modifiable factor associated with lower psychological and behavioral risk among adolescents. It includes bodily movements that increase energy expenditure, such as daily activity, structured exercise, and sports participation (de Gregorio et al. 2018; Dasso 2019; Król et al.

2022; Puchalska-Sarna et al. 2022). Higher levels of physical activity have been associated with lower depression, anxiety, and behavioral problems, as well as better emotion regulation, self-control, and social adaptation (Spruit et al. 2016; Choi et al. 2019; Jin et al. 2023; Zhou et al. 2024; Yue et al. 2025; Zhao et al. 2025; Chen et al. 2026). Physical activity also has practical relevance in school settings because it can be incorporated into physical education, after-school programs, student clubs, and community-based sports activities (Willeboordse et al. 2016; Mavilidi et al. 2019; Morano et al. 2020; Carducci et al. 2024). Therefore, the present study examined whether physical activity statistically moderated the association between negative urgency–related emotional impulsiveness and NSSI. Given the observational and cross-sectional design, any observed moderation should be interpreted as an association pattern rather than evidence that physical activity produces a clinically protective effect.

Most previous studies of adolescent NSSI have used variable-centered approaches, such as regression, mediation, and moderation analyses. These approaches are useful for estimating overall associations among constructs but may obscure differences among the specific dimensions of multidimensional variables (Reinhardt et al. 2022; de Neve-Enthoven et al. 2024; Liu et al. 2024). Childhood trauma, NSSI, and physical activity each contain distinct components that may differ in their associations with emotional impulsiveness and Internet addiction.

Network analysis provides a complementary method for examining conditional associations among specific dimensions and composite constructs within a broader psychological and behavioral system (Bringmann et al. 2016; Guyon et al. 2017; Modafferi et al. 2023; Zhang et al. 2026). Centrality indices describe the overall connectivity of individual nodes, whereas bridge indices identify nodes that connect theoretically defined variable communities (Guan et al. 2024; Jiang et al. 2026). Combining network analysis with variable-centered models may therefore provide a more detailed description of how childhood trauma, emotional impulsiveness, Internet addiction, physical activity, and NSSI are interconnected.

However, edges in a cross-sectional network represent conditional associations after accounting for the other included nodes; they do not indicate temporal direction, causal influence, or developmental progression. Accordingly, the network analysis in this study was used to identify patterns of connectivity and potential bridge nodes, rather than to establish causal pathways or intervention targets.

Taken together, previous research has identified associations among childhood trauma, negative urgency–related emotional impulsiveness, Internet addiction, physical activity, and adolescent NSSI. However, few studies have integrated these variables within a single analytical framework combining indirect-effect analysis, moderation analysis, and network analysis. It therefore remains unclear whether emotional impulsiveness and Internet addiction show separate or sequential indirect associations between childhood trauma and NSSI, whether physical activity moderates the emotional impulsiveness–NSSI association, and which specific dimensions or constructs serve as bridge nodes within the broader network.

Accordingly, using data from a large sample of Chinese adolescents, the present study combined sequential mediation analysis, a separate moderation analysis, and a 12-node network analysis. The study examined: (1) the indirect associations of childhood trauma with NSSI through emotional impulsiveness and Internet addiction; (2) whether physical activity moderated the association between emotional impulsiveness and NSSI; and (3) the central and bridge nodes connecting childhood trauma, emotional impulsiveness, Internet addiction, physical activity, and NSSI. Because the data were cross-sectional, all mediation, moderation, and network findings were interpreted as statistical association patterns rather than evidence of temporal or causal relationships.

Based on the theoretical rationale and previous empirical findings, the following hypotheses were proposed:

H1: Childhood trauma is positively associated with adolescent NSSI.

H2: Childhood trauma is positively associated with negative urgency–related emotional impulsiveness and Internet addiction.

H3: Negative urgency–related emotional impulsiveness is positively associated with Internet addiction and adolescent NSSI.

H4: Internet addiction is positively associated with adolescent NSSI and shows a significant indirect association between childhood trauma and NSSI.

H5: Negative urgency–related emotional impulsiveness and Internet addiction form a significant sequential indirect association between childhood trauma and adolescent NSSI.

H6: Physical activity is negatively associated with Internet addiction and significantly moderates the association between emotional impulsiveness and adolescent NSSI, such that this positive association is weaker at higher levels of physical activity.

## **2. Methods**

### **2.1 Participants and Procedure**

This study used a cross-sectional questionnaire design. In June 2025, participants were recruited from secondary schools located in six provinces of China—Sichuan, Hubei, Guangxi, Gansu, Hebei, and Fujian—using convenience sampling. A total of 2,000 questionnaires were distributed. Responses were excluded if they contained substantial missing data, duplicated submissions, highly patterned responses suggesting careless completion, or an implausibly short completion time. After data screening, 1,869 valid questionnaires were retained, corresponding to a valid response rate of 93.45%.

The final sample included 864 male participants (46.23%) and 1005 female participants (53.77%), with a mean age of 14.61 years ( $SD = 1.45$ ). Additional demographic characteristics, including grade, residential

background, only-child status, left-behind status, boarding status, and parental education, are presented in Table 1.

Table 1  
Demographic characteristics of participants (N = 1,869). Age: 14.63 ± 1.45 years

| Variable                                                                                                              | Classification                            | Number | Proportion (%) |
|-----------------------------------------------------------------------------------------------------------------------|-------------------------------------------|--------|----------------|
| Gender                                                                                                                | Male                                      | 864    | 46.23          |
|                                                                                                                       | Female                                    | 1005   | 53.77          |
| Grade                                                                                                                 | 7th                                       | 308    | 16.48          |
|                                                                                                                       | 8th                                       | 954    | 51.04          |
|                                                                                                                       | 9th                                       | 154    | 8.24           |
|                                                                                                                       | 10th                                      | 133    | 7.12           |
|                                                                                                                       | 11th                                      | 236    | 12.63          |
|                                                                                                                       | 12th                                      | 84     | 4.49           |
| Residential background                                                                                                | Urban/town                                | 328    | 17.55          |
|                                                                                                                       | Rural                                     | 1541   | 82.45          |
| Only child                                                                                                            | Yes                                       | 168    | 8.99           |
|                                                                                                                       | No                                        | 1701   | 91.01          |
| Left-behind                                                                                                           | Yes                                       | 587    | 31.41          |
|                                                                                                                       | No                                        | 1282   | 68.59          |
| Boarding                                                                                                              | Yes                                       | 1438   | 76.94          |
|                                                                                                                       | No                                        | 431    | 23.06          |
| Paternal education level                                                                                              | Primary school or no schooling            | 694    | 37.13          |
|                                                                                                                       | Junior middle school                      | 719    | 38.47          |
|                                                                                                                       | High school or technical secondary school | 209    | 11.18          |
|                                                                                                                       | College/university                        | 59     | 3.16           |
|                                                                                                                       | Postgraduate                              | 11     | 0.59           |
|                                                                                                                       | Unknown                                   | 177    | 9.47           |
| Maternal education level                                                                                              | Primary school or no schooling            | 867    | 46.39          |
|                                                                                                                       | Junior middle school                      | 639    | 34.19          |
| <b>Note.</b> Values are presented as n (%) unless otherwise indicated. Age is presented as mean ± standard deviation. |                                           |        |                |

| Variable                                                                                                              | Classification                            | Number | Proportion (%) |
|-----------------------------------------------------------------------------------------------------------------------|-------------------------------------------|--------|----------------|
|                                                                                                                       | High school or technical secondary school | 202    | 10.81          |
|                                                                                                                       | College/university                        | 43     | 2.30           |
|                                                                                                                       | Postgraduate                              | 11     | 0.59           |
|                                                                                                                       | Unknown                                   | 107    | 5.72           |
| <b>Note.</b> Values are presented as n (%) unless otherwise indicated. Age is presented as mean ± standard deviation. |                                           |        |                |

Before questionnaire administration, trained members of the research team explained the study purpose, survey procedures, voluntary nature of participation, confidentiality protections, and the participants’ right to withdraw without penalty. Questionnaires were completed anonymously. Because all participants were minors, informed consent was obtained from their legal guardians, and assent was obtained from the adolescents before participation. Data collection was conducted with the cooperation of the participating schools.

The study protocol was reviewed and approved by the Biomedical Ethics Committee of Jishou University, China (approval number: JSDX-2025-0071), and all procedures were conducted in accordance with the Declaration of Helsinki and relevant Chinese regulations governing research involving human participants.

## 2.2 Measures

### 2.2.1 Childhood Trauma

Childhood trauma was assessed using the Chinese version of the Childhood Trauma Questionnaire–Short Form (CTQ-SF-C)(Bernstein et al. 2003; Fu and Yao 2005). The questionnaire contains 28 items, of which 25 assess five dimensions of childhood trauma: emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect. The remaining three items constitute the minimization/denial validity scale and were not included in the calculation of the childhood trauma score. Items are rated on a 5-point Likert scale ranging from 1 (“never”) to 5 (“always”), with designated emotional-neglect items reverse-coded. Mean scores were calculated for the five trauma dimensions and for the overall childhood trauma construct, with higher scores indicating greater exposure to childhood trauma. Previous studies have supported the reliability and validity of the CTQ-SF-C in Chinese populations. In the present study, Cronbach’s  $\alpha$  for the 25 trauma items was 0.933, indicating good internal consistency.

### 2.2.2 Emotional Impulsiveness

In the present study, emotional impulsiveness was operationalized specifically as negative urgency, defined as the tendency to act rashly or impulsively when experiencing intense negative emotions. It was assessed using the 12-item Negative Urgency subscale of the UPPS Impulsive Behavior Scale(Whiteside

and Lynam 2001). Items are rated on a 4-point scale ranging from 1 (“strongly agree”) to 4 (“strongly disagree”). Items were coded according to the scoring instructions so that higher scores consistently represented greater negative urgency. A mean score was calculated across the completed items, with higher scores indicating a stronger tendency to engage in impulsive behavior under negative affect. Throughout the manuscript, the term emotional impulsiveness refers specifically to this negative urgency–related construct. In the present study, Cronbach’s  $\alpha$  for the Negative Urgency subscale was 0.873, indicating good internal consistency.

### **2.2.3 Internet Addiction**

Internet addiction was assessed using Young’s Internet Addiction Test (IAT)(Young 2009; Hawi 2013). In this study, Internet addiction refers specifically to problematic Internet-use tendencies characterized by impaired control, excessive dependence, functional interference, and persistent negative consequences. The IAT contains 20 items rated on a 5-point Likert scale ranging from 1 (“rarely”) to 5 (“always”). Item scores were summed to produce a total score ranging from 20 to 100, with higher scores indicating more pronounced Internet addiction tendencies. The total IAT score was analyzed as a continuous variable rather than being used to assign participants to diagnostic categories. Previous studies have supported the reliability and validity of the IAT among adolescents. In the present study, Cronbach’s  $\alpha$  was 0.964, indicating excellent internal consistency.

### **2.2.4 Adolescent Non-Suicidal Self-Injury**

Adolescent NSSI was assessed using the Adolescent Non-Suicidal Self-Injury Assessment Questionnaire (ANSAQ)(Wan et al. 2018). The questionnaire contains 31 items divided into two dimensions. The NSSI behavior dimension comprises 12 items assessing the frequency of specific forms of self-injurious behavior and is rated on a 5-point frequency scale ranging from 1 (“never”) to 5 (“always”). The NSSI function dimension comprises 19 items assessing the reasons or functions associated with these behaviors and is rated on a 5-point agreement scale ranging from 1 (“completely inconsistent”) to 5 (“completely consistent”). Mean scores were calculated for the NSSI behavior dimension, the NSSI function dimension, and the overall NSSI construct. Higher scores indicate more frequent NSSI behaviors and stronger endorsement of NSSI-related functions. The overall mean score was used in the variable-centered analyses, whereas the behavior and function dimension scores were entered as separate nodes in the network analysis. In the present study, Cronbach’s  $\alpha$  for the full questionnaire was 0.897, indicating good internal consistency.

### **2.2.5 Physical Activity**

Physical activity was assessed using the Physical Activity Rating Scale-3 (PARS-3)(Deqing 1994). The scale consists of three items assessing exercise intensity, exercise duration, and exercise frequency, with each component rated on a 5-point scale. The overall physical activity score was calculated using the following formula: Exercise intensity  $\times$  (exercise duration – 1)  $\times$  exercise frequency. The resulting score ranges from 0 to 100, with higher scores indicating greater participation in physical activity. The overall PARS-3 score was used in the correlation and regression-based analyses, whereas exercise

intensity, duration, and frequency were entered as separate nodes in the network analysis. Cronbach's  $\alpha$  across the three components was 0.805. However, because PARS-3 combines conceptually distinct components into a multiplicative index, this coefficient was treated as supplementary information rather than evidence that the three components represent a unidimensional construct.

## 2.3 Statistical Analysis

Statistical analyses were conducted using SPSS version 27.0 and the PROCESS macro. Descriptive statistics were first calculated for the principal study variables, followed by Pearson correlation analyses to examine their bivariate associations. Harman's single-factor test was used as a preliminary diagnostic assessment of common method bias. A first unrotated factor accounting for less than 40% of the total variance was considered not to indicate substantial common method bias, although this test alone cannot exclude all potential bias associated with self-report data.

A sequential mediation analysis was conducted using PROCESS Model 6. Childhood trauma was entered as the independent variable, NSSI as the dependent variable, and emotional impulsiveness and Internet addiction as the first and second mediators, respectively. Gender and age were included as covariates. Indirect associations were evaluated using 5,000 bootstrap resamples with 95% confidence intervals. An indirect association was considered statistically significant when its bootstrap confidence interval did not include zero. Because the data were cross-sectional, the mediation model was used to estimate theoretically specified statistical indirect associations rather than temporal or causal pathways.

A separate moderation analysis was subsequently conducted to examine whether physical activity moderated the association between emotional impulsiveness and NSSI. Emotional impulsiveness, physical activity, and their interaction term were entered as predictors, with childhood trauma, Internet addiction, gender, and age included as covariates. Continuous variables used in the interaction analysis were standardized before the interaction term was constructed to reduce nonessential multicollinearity and facilitate interpretation. When the interaction term was statistically significant, simple-slope analyses were performed at low ( $M - 1\text{ SD}$ ), mean ( $M$ ), and high ( $M + 1\text{ SD}$ ) levels of physical activity.

The moderation analysis was conducted separately from the sequential mediation model and did not constitute a conditional indirect-effect or moderated-mediation model. Accordingly, the interaction result was interpreted only as evidence that the strength of the emotional impulsiveness–NSSI association differed across physical activity levels. All tests were two-tailed, and statistical significance was set at  $p < 0.05$ . Standardized regression coefficients are reported where applicable.

## 2.4 Network Analysis

Network analysis was conducted in R using the qqgraph, bootnet, networktools, and mgm packages. Each node represented a theoretically defined dimension or composite construct, and each edge represented the conditional association between two nodes after accounting for all other nodes in the network. Thicker edges indicated stronger conditional associations. Because the network was based on cross-

sectional data, edges were interpreted as undirected conditional associations rather than temporal or causal relationships.

A 12-node network was constructed to balance theoretical specificity, model parsimony, and interpretability. Childhood trauma was represented by five established CTQ-SF dimensions: emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect. Emotional impulsiveness was represented by the overall mean score of the Negative Urgency subscale. Internet addiction was represented by the total IAT score. NSSI was represented by two dimensions: NSSI behavior and NSSI function. Physical activity was represented by exercise intensity, exercise duration, and exercise frequency. The abbreviations and predefined community assignments of the 12 nodes are presented in Fig. 3.

The mixed use of dimension scores and composite scores reflected the theoretical and measurement structures of the instruments. Childhood trauma, NSSI, and physical activity were represented by their established dimensions because these components have distinct conceptual meanings and were directly relevant to the study questions. In contrast, emotional impulsiveness and Internet addiction were represented as composite nodes because the study focused on overall negative urgency and overall Internet addiction tendencies rather than their individual items. This approach reduced excessive network complexity while preserving the multidimensional structures most relevant to the hypotheses. Nevertheless, the use of different levels of aggregation may affect centrality and bridge estimates and was therefore considered when interpreting the results.

Before network estimation, the nodes were examined for conceptual redundancy and excessively high correlations. No node pair was identified as sufficiently redundant to require combination or removal. The network was estimated using an EBICglasso regularized partial-correlation model. The least absolute shrinkage and selection operator was used to reduce potentially spurious associations and produce a more interpretable network, and model selection was performed using the extended Bayesian information criterion with the tuning parameter  $\gamma$  set to 0.50. Network visualization used the Fruchterman–Reingold algorithm, which places more strongly connected nodes closer together without implying temporal ordering.

Node strength and expected influence were calculated to describe node connectivity. Strength represents the sum of the absolute edge weights connected to a node, whereas expected influence retains the signs of the edge weights. Bridge strength and bridge expected influence were calculated using the predefined variable communities to describe connections between constructs. Node predictability was also estimated to quantify the proportion of variance in each node statistically accounted for by its neighboring nodes.

Because the emotional impulsiveness and Internet addiction communities each contained a single node and the predefined communities differed in size, bridge indices were interpreted descriptively and comparatively rather than as definitive evidence of causal importance or intervention priority. Similarly,

node predictability was interpreted as statistical shared variance within the network and not as evidence that changing neighboring nodes would produce changes in the target node.

## 2.5 Network Accuracy and Stability

The accuracy and stability of the estimated network were evaluated using the bootnet package. First, nonparametric bootstrap analysis was used to calculate 95% confidence intervals for the edge weights. Narrower confidence intervals were interpreted as indicating greater precision of the estimated edges, whereas overlapping confidence intervals were not interpreted as evidence that individual edge weights differed significantly.

Second, case-dropping bootstrap analysis was conducted to evaluate the stability of node strength and expected influence. Stability was quantified using the correlation stability coefficient (CS coefficient), which represents the maximum proportion of cases that can be removed while retaining, with 95% probability, a correlation of at least 0.70 between the centrality estimates from the reduced and original samples. A CS coefficient above 0.25 was considered minimally acceptable, whereas a value above 0.50 indicated good stability.

Because separate CS coefficients for bridge strength and bridge expected influence were not available, bridge indices were interpreted descriptively and were not treated as independently validated indicators of intervention priority. In addition, all accuracy and stability analyses evaluated the statistical robustness of the cross-sectional network estimates and did not provide evidence of temporal direction or causality.

## 3. Results

### 3.1 Common Method Bias, Descriptive Statistics, and Correlation Analysis

Harman's single-factor test showed that the first unrotated factor accounted for 20.79% of the total variance, which was below the prespecified 40% threshold. This result did not indicate substantial common method bias according to this preliminary diagnostic test. However, because all variables were assessed using self-report measures, the possibility of residual common method bias could not be completely excluded.

The descriptive statistics and Pearson correlations among the principal study variables are presented in Table 2. Childhood trauma was positively correlated with emotional impulsiveness, Internet addiction, and NSSI ( $r = 0.365$ – $0.508$ , all  $p < 0.001$ ). The strongest of these correlations was observed between childhood trauma and Internet addiction ( $r = 0.508$ ,  $p < 0.001$ ), followed by childhood trauma and NSSI ( $r = 0.392$ ,  $p < 0.001$ ) and childhood trauma and emotional impulsiveness ( $r = 0.365$ ,  $p < 0.001$ ). Emotional impulsiveness was positively correlated with NSSI ( $r = 0.511$ ,  $p < 0.001$ ) and Internet addiction ( $r = 0.271$ ,  $p < 0.001$ ). Internet addiction was also positively correlated with NSSI ( $r = 0.302$ ,  $p < 0.001$ ). Physical

activity was negatively correlated with childhood trauma ( $r = -0.057$ ,  $p = 0.013$ ), emotional impulsiveness ( $r = -0.194$ ,  $p < 0.001$ ), Internet addiction ( $r = -0.277$ ,  $p < 0.001$ ), and NSSI ( $r = -0.186$ ,  $p < 0.001$ ). These results describe bivariate associations and do not indicate temporal or causal relationships.

Table 2  
Descriptive statistics and correlations among main variables.

| Variable                                                                                                                                                                                      | M     | SD    | 1        | 2         | 3         | 4         | 5     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|----------|-----------|-----------|-----------|-------|
| Childhood trauma                                                                                                                                                                              | 2.66  | 0.63  | 1.000    |           |           |           |       |
| Emotional impulsiveness                                                                                                                                                                       | 2.33  | 0.61  | 0.365*** | 1.000     |           |           |       |
| Internet Addiction Test (IAT)                                                                                                                                                                 | 45.71 | 18.18 | 0.508*** | 0.271***  | 1.000     |           |       |
| NSSI                                                                                                                                                                                          | 1.16  | 0.24  | 0.392*** | 0.511***  | 0.302***  | 1.000     |       |
| Physical activity                                                                                                                                                                             | 11.98 | 13.10 | -0.057*  | -0.194*** | -0.277*** | -0.186*** | 1.000 |
| <b>Note.</b> NSSI = non-suicidal self-injury; IAT = Internet Addiction Test. * $p < 0.05$ , ** $p < 0.01$ , *** $p < 0.001$ . All reported coefficients are Pearson correlation coefficients. |       |       |          |           |           |           |       |

## 3.2 Sequential Mediation Analysis

PROCESS Model 6 was used to estimate the indirect associations of childhood trauma with NSSI through emotional impulsiveness and Internet addiction, with gender and age included as covariates. The regression results are presented in Table 3, and the model is illustrated in Fig. 1.

In the total-association model, childhood trauma was positively associated with NSSI ( $\beta = 0.392$ ,  $SE = 0.021$ ,  $t = 18.404$ ,  $p < 0.001$ ), and the model explained 15.40% of the variance in NSSI. Childhood trauma was also positively associated with emotional impulsiveness ( $\beta = 0.365$ ,  $SE = 0.022$ ,  $t = 16.956$ ,  $p < 0.001$ ), with the model explaining 13.40% of the variance in emotional impulsiveness.

In the model with Internet addiction as the dependent variable, childhood trauma was positively associated with Internet addiction ( $\beta = 0.473$ ,  $SE = 0.021$ ,  $t = 22.203$ ,  $p < 0.001$ ). Emotional impulsiveness was also positively associated with Internet addiction after accounting for childhood trauma, gender, and age ( $\beta = 0.098$ ,  $SE = 0.021$ ,  $t = 4.586$ ,  $p < 0.001$ ). This model explained 26.80% of the variance in Internet addiction.

When childhood trauma, emotional impulsiveness, and Internet addiction were entered simultaneously into the NSSI model, childhood trauma remained positively associated with NSSI ( $\beta = 0.194$ ,  $SE = 0.023$ ,  $t = 8.360$ ,  $p < 0.001$ ). Emotional impulsiveness ( $\beta = 0.416$ ,  $SE = 0.021$ ,  $t = 20.100$ ,  $p < 0.001$ ) and Internet addiction ( $\beta = 0.092$ ,  $SE = 0.022$ ,  $t = 4.089$ ,  $p < 0.001$ ) were also positively associated with NSSI. The final model explained 31.60% of the variance in NSSI.

The reduction in the childhood trauma coefficient after emotional impulsiveness and Internet addiction were included was consistent with partial statistical mediation. However, because all variables were measured cross-sectionally, these results indicate theoretically specified indirect associations and do not establish that emotional impulsiveness or Internet addiction temporally mediated the association between childhood trauma and NSSI.

Table 3  
Regression results for the sequential mediation analysis.

| Dependent variable                                                                                                                                                                                                                              | Predictor                     | R <sup>2</sup> | F          | $\beta$ | SE    | t         | 95% CI         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|----------------|------------|---------|-------|-----------|----------------|
| NSSI                                                                                                                                                                                                                                            | Childhood trauma              | 0.154          | 113.103*** | 0.392   | 0.021 | 18.404*** | [0.350, 0.434] |
| Emotional Impulsiveness                                                                                                                                                                                                                         | Childhood trauma              | 0.134          | 96.490***  | 0.365   | 0.022 | 16.956*** | [0.323, 0.408] |
| Internet Addiction Test, IAT                                                                                                                                                                                                                    | Childhood trauma              | 0.268          | 170.300*** | 0.473   | 0.021 | 22.203*** | [0.431, 0.515] |
| Internet Addiction Test (IAT)                                                                                                                                                                                                                   | Emotional impulsiveness       | 0.268          | 170.300*** | 0.098   | 0.021 | 4.586***  | [0.056, 0.139] |
| NSSI                                                                                                                                                                                                                                            | Childhood trauma              | 0.316          | 172.513*** | 0.194   | 0.023 | 8.360***  | [0.148, 0.239] |
| NSSI                                                                                                                                                                                                                                            | Emotional impulsiveness       | 0.316          | 172.513*** | 0.416   | 0.021 | 20.100*** | [0.376, 0.457] |
| NSSI                                                                                                                                                                                                                                            | Internet Addiction Test (IAT) | 0.316          | 172.513*** | 0.092   | 0.022 | 4.089***  | [0.048, 0.135] |
| <b>Note.</b> Gender and age were included as covariates in all regression models. $\beta$ values are standardized regression coefficients. NSSI = non-suicidal self-injury; IAT = Internet Addiction Test. *p < 0.05, **p < 0.01, ***p < 0.001. |                               |                |            |         |       |           |                |

### 3.3 Bootstrap Analysis of Indirect Effects

Bootstrap analysis with 5,000 resamples was used to evaluate the indirect associations specified in the sequential mediation model. The results are presented in Table 4. The total association between childhood trauma and NSSI was 0.392. After emotional impulsiveness and Internet addiction were included, the remaining direct association was 0.194, accounting for 49.35% of the total association. The combined indirect association was 0.199, accounting for 50.65% of the total association.

The indirect association through emotional impulsiveness alone was statistically significant (Effect = 0.152, Boot SE = 0.012, 95% CI [0.130, 0.176]) and accounted for 38.78% of the total association. The indirect association through Internet addiction alone was also significant (Effect = 0.043, Boot SE = 0.012, 95% CI [0.021, 0.066]) and accounted for 11.04% of the total association. The sequential indirect

association through emotional impulsiveness and Internet addiction was statistically significant (Effect = 0.003, Boot SE = 0.001, 95% CI [0.001, 0.006]) but accounted for only 0.83% of the total association.

Comparisons among the three indirect associations showed that the association through emotional impulsiveness alone was significantly larger than those through Internet addiction alone and through the sequential route. Overall, emotional impulsiveness represented the largest indirect association between childhood trauma and NSSI. Internet addiction showed a smaller indirect association, whereas the sequential indirect association was statistically detectable but limited in magnitude. These estimates represent the statistical decomposition of cross-sectional associations and should not be interpreted as evidence of temporal mediation or developmental progression.

Table 4  
Bootstrap estimates of indirect associations between childhood trauma and NSSI.

| Mediation pathway                                                                                                                                                                                                                                                                                                                                                  | Effect | Boot SE | Boot LLCI | Boot ULCI | Relative effect |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|---------|-----------|-----------|-----------------|
| Total association                                                                                                                                                                                                                                                                                                                                                  | 0.392  | 0.022   | 0.350     | 0.436     | —               |
| Remaining direct association                                                                                                                                                                                                                                                                                                                                       | 0.194  | 0.022   | 0.150     | 0.237     | 49.35%          |
| Combined indirect association                                                                                                                                                                                                                                                                                                                                      | 0.199  | 0.017   | 0.167     | 0.232     | 50.65%          |
| CTQ → emotional impulsiveness → NSSI                                                                                                                                                                                                                                                                                                                               | 0.152  | 0.012   | 0.130     | 0.176     | 38.78%          |
| CTQ → Internet addiction (IAT) → NSSI                                                                                                                                                                                                                                                                                                                              | 0.043  | 0.012   | 0.021     | 0.066     | 11.04%          |
| CTQ → emotional impulsiveness → Internet addiction (IAT) → NSSI                                                                                                                                                                                                                                                                                                    | 0.003  | 0.001   | 0.001     | 0.006     | 0.83%           |
| Ind1 - Ind2                                                                                                                                                                                                                                                                                                                                                        | 0.109  | 0.017   | 0.076     | 0.142     | —               |
| Ind1 - Ind3                                                                                                                                                                                                                                                                                                                                                        | 0.149  | 0.012   | 0.127     | 0.173     | —               |
| Ind2 - Ind3                                                                                                                                                                                                                                                                                                                                                        | 0.040  | 0.011   | 0.020     | 0.062     | —               |
| <b>Note.</b> Ind1 = childhood trauma → emotional impulsiveness → NSSI; Ind2 = childhood trauma → Internet addiction → NSSI; Ind3 = childhood trauma → emotional impulsiveness → Internet addiction → NSSI. Bootstrap estimates are based on 5,000 resamples. An indirect association is statistically significant when its 95% bootstrap CI does not include zero. |        |         |           |           |                 |

### 3.4 Moderating Effect of Physical Activity

A separate regression-based moderation analysis was conducted to examine whether physical activity moderated the association between emotional impulsiveness and NSSI after controlling for childhood trauma, Internet addiction, gender, and age. The results are presented in Table 5.

Emotional impulsiveness was positively associated with NSSI ( $\beta = 0.397$ ,  $SE = 0.021$ ,  $t = 19.284$ ,  $p < 0.001$ ), whereas physical activity was negatively associated with NSSI ( $\beta = -0.138$ ,  $SE = 0.021$ ,  $t = -$

6.480,  $p < 0.001$ ). Internet addiction showed a small but statistically significant positive association with NSSI ( $\beta = 0.050$ ,  $SE = 0.023$ ,  $t = 2.185$ ,  $p = 0.029$ ). The interaction between emotional impulsiveness and physical activity was statistically significant ( $\beta = -0.155$ ,  $SE = 0.019$ ,  $t = -7.968$ ,  $p < 0.001$ ), indicating that the strength of the emotional impulsiveness–NSSI association differed across levels of physical activity.

Simple-slope analyses showed that emotional impulsiveness was positively associated with NSSI at all three examined levels of physical activity. The association was strongest at low physical activity ( $\beta = 0.552$ ,  $p < 0.001$ , 95% CI [0.497, 0.606]), remained positive at the mean level of physical activity ( $\beta = 0.397$ ,  $p < 0.001$ , 95% CI [0.357, 0.437]), and was weaker at high physical activity ( $\beta = 0.242$ ,  $p < 0.001$ , 95% CI [0.186, 0.299]).

Thus, higher physical activity was statistically associated with a weaker positive association between emotional impulsiveness and NSSI. However, emotional impulsiveness remained significantly associated with NSSI even at high physical activity. This result therefore indicates statistical moderation and does not demonstrate that physical activity eliminates NSSI risk or produces a clinically protective effect. The interaction pattern is shown in Fig. 2.

Table 5  
Moderation of the emotional impulsiveness–NSSI association by physical activity.

| Predictor                                                                                                                                                                                                                                                                                                                       | $\beta$ | SE    | t      | p       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------|--------|---------|
| Childhood trauma                                                                                                                                                                                                                                                                                                                | 0.219   | 0.023 | 9.521  | < 0.001 |
| Internet Addiction Test (IAT)                                                                                                                                                                                                                                                                                                   | 0.050   | 0.023 | 2.185  | 0.029   |
| Emotional impulsiveness                                                                                                                                                                                                                                                                                                         | 0.397   | 0.021 | 19.284 | < 0.001 |
| Physical activity                                                                                                                                                                                                                                                                                                               | -0.138  | 0.021 | -6.480 | < 0.001 |
| Emotional impulsiveness $\times$ Physical activity                                                                                                                                                                                                                                                                              | -0.155  | 0.019 | -7.968 | < 0.001 |
| Gender                                                                                                                                                                                                                                                                                                                          | 0.041   | 0.038 | 1.097  | 0.273   |
| Age                                                                                                                                                                                                                                                                                                                             | -0.019  | 0.019 | -1.036 | 0.301   |
| <b>Note.</b> The dependent variable was NSSI. Childhood trauma, Internet addiction, gender, and age were included as covariates. Continuous predictors used in the interaction term were standardized. $\beta$ values are standardized regression coefficients. NSSI = non-suicidal self-injury; IAT = Internet Addiction Test. |         |       |        |         |

### 3.5 Network Structure Analysis

A 12-node EBICglasso network was estimated to examine conditional associations among childhood trauma, emotional impulsiveness, Internet addiction, physical activity, and NSSI. The network included five childhood trauma dimensions, the composite emotional impulsiveness score, the total IAT score, two NSSI dimensions, and three physical activity indicators. Examination of conceptual overlap and inter-node correlations did not identify any node pair requiring combination or removal.

The estimated network is shown in Fig. 3. Of the 66 possible edges, 53 were estimated as nonzero, corresponding to a network density of 80.30%. Among these edges, 42 were positive and 11 were negative. The strongest conditional association was observed between NSSI behavior and NSSI function (NSSI\_B–NSSI\_F,  $w = 0.549$ ). Other relatively strong within-community associations included exercise duration–exercise frequency (PA\_D–PA\_F,  $w = 0.348$ ), exercise intensity–exercise duration (PA\_I–PA\_D,  $w = 0.348$ ), exercise intensity–exercise frequency (PA\_I–PA\_F,  $w = 0.328$ ), emotional abuse–emotional neglect (EA–EN,  $w = 0.263$ ), and sexual abuse–emotional neglect (SA–EN,  $w = 0.238$ ). These edges indicated relatively strong within-community connectivity.

Among the between-community edges, the strongest positive conditional association was observed between emotional impulsiveness and NSSI behavior (EI–NSSI\_B,  $w = 0.212$ ), followed by emotional impulsiveness and NSSI function (EI–NSSI\_F,  $w = 0.170$ ). Physical neglect was positively associated with Internet addiction (PN–IAT,  $w = 0.093$ ), followed by emotional neglect–Internet addiction (EN–IAT,  $w = 0.072$ ) and sexual abuse–Internet addiction (SA–IAT,  $w = 0.070$ ).

Internet addiction showed negative conditional associations with exercise duration (IAT–PA\_D,  $w = -0.111$ ), exercise frequency (IAT–PA\_F,  $w = -0.089$ ), and exercise intensity (IAT–PA\_I,  $w = -0.084$ ). Emotional impulsiveness was also negatively associated with exercise duration (EI–PA\_D,  $w = -0.052$ ) and exercise frequency (EI–PA\_F,  $w = -0.044$ ). These edges represent conditional associations after accounting for the remaining nodes and do not indicate temporal or causal relationships.

### 3.6 Node Predictability, Centrality, and Bridge Nodes

Node predictability values ranged from 0.312 to 0.701, with a mean of 0.534. Thus, on average, approximately 53.4% of the variance in each node was statistically accounted for by its neighboring nodes in the estimated network. Sexual abuse showed the highest predictability ( $R^2 = 0.701$ ), followed by emotional neglect ( $R^2 = 0.698$ ), emotional abuse ( $R^2 = 0.685$ ), physical abuse ( $R^2 = 0.680$ ), and physical neglect ( $R^2 = 0.670$ ). NSSI behavior and NSSI function showed predictability values of 0.517 and 0.495, respectively. Emotional impulsiveness showed the lowest predictability ( $R^2 = 0.312$ ), followed by Internet addiction ( $R^2 = 0.348$ ). These values represent statistical shared variance and should not be interpreted causally.

For node strength, sexual abuse showed the highest value (Strength = 1.083), followed by emotional neglect (Strength = 1.051), emotional abuse (Strength = 1.001), physical neglect (Strength = 0.992), and physical abuse (Strength = 0.990). The same five childhood-trauma nodes also showed the highest positive expected influence values, with sexual abuse showing the highest expected influence (Expected Influence = 1.083), followed by emotional neglect (Expected Influence = 1.051), emotional abuse (Expected Influence = 1.001), physical neglect (Expected Influence = 0.992), and physical abuse (Expected Influence = 0.990).

The bridge indices are shown in Fig. 4. Internet addiction had the highest bridge strength (Bridge Strength = 0.709), followed by emotional impulsiveness (Bridge Strength = 0.649), NSSI behavior (Bridge

Strength = 0.366), NSSI function (Bridge Strength = 0.315), and exercise duration (Bridge Strength = 0.234).

Emotional impulsiveness had the highest bridge expected influence (Bridge Expected Influence = 0.420), followed by NSSI behavior (Bridge Expected Influence = 0.295), NSSI function (Bridge Expected Influence = 0.211), sexual abuse (Bridge Expected Influence = 0.184), and physical neglect (Bridge Expected Influence = 0.166). Exercise duration, exercise frequency, and exercise intensity showed negative bridge expected influence values of  $-0.149$ ,  $-0.131$ , and  $-0.092$ , respectively. These negative values indicate that physical activity nodes were predominantly connected to nodes in other communities through negative conditional associations.

Because emotional impulsiveness and Internet addiction were represented as single-node communities, whereas the other communities contained multiple nodes, bridge rankings were interpreted descriptively. Differences in community size and node aggregation may influence bridge indices, and these rankings should not be interpreted as evidence of causal importance or intervention priority.

### **3.7 Network Accuracy and Stability**

Bootstrap analyses were conducted to evaluate the accuracy of the estimated edge weights and the stability of node centrality. The nonparametric bootstrap results showed that the 95% confidence intervals for the stronger edge weights were generally narrower than those for weaker edges, indicating comparatively greater precision for the principal network associations. Nevertheless, several confidence intervals overlapped, and the relative ordering of edges with similar weights should therefore be interpreted cautiously.

The case-dropping bootstrap analysis produced CS coefficients of 0.750 for both node strength and expected influence. These values exceeded the recommended threshold of 0.50, indicating good stability of the rankings for these two centrality indices after subsets of participants were removed.

Separate CS coefficients for bridge strength and bridge expected influence were not available. Consequently, the stability of the bridge-node rankings was not independently established, and these results were interpreted descriptively. Overall, the bootstrap findings supported the stability of node strength and expected influence but did not provide evidence regarding causal direction or the stability of the bridge indices.

## **4. Discussion**

Using cross-sectional data from 1,869 Chinese adolescents, this study examined the associations among childhood trauma, negative urgency–related emotional impulsiveness, Internet addiction, physical activity, and NSSI through complementary variable-centered and network approaches. Emotional impulsiveness showed the largest indirect association between childhood trauma and NSSI, whereas the indirect association through Internet addiction was smaller and the sequential indirect association accounted for only 0.83% of the total association. Physical activity statistically moderated

the emotional impulsiveness–NSSI association, although emotional impulsiveness remained positively associated with NSSI at all examined physical activity levels. The network analysis further examined conditional connections among the study constructs. These findings should be interpreted as cross-sectional association patterns rather than evidence of developmental progression, causal mechanisms, or clinically protective effects.

## **4.1 Association Between Childhood Trauma and Adolescent NSSI**

Childhood trauma was positively associated with adolescent NSSI, supporting H1 and aligning with previous evidence identifying childhood trauma as an important distal correlate of self-injurious behavior (Brodsky 2016; Liu et al. 2018; Farooq et al. 2025). Childhood trauma commonly reflects repeated exposure to threat, emotional unresponsiveness, neglect, unstable caregiving, and inadequate family support rather than a single isolated event (McLaughlin et al. 2020; Hays-Grudo et al. 2021; Paetzold et al. 2023; Machlin et al. 2025). Such experiences have been associated with lower perceived security and self-worth, impaired interpersonal trust, and greater difficulties in emotion regulation and stress coping (Villalta et al. 2018; Wiseman et al. 2021; Weiss et al. 2023). These emotional and behavioral difficulties may help explain why childhood trauma and NSSI frequently co-occur during adolescence.

NSSI may function as a short-term strategy for reducing intense distress, interrupting emotional numbness, or restoring a subjective sense of control (Miller et al. 2018; Mayo et al. 2021; Lewis and Hasking 2025). Adolescents exposed to childhood trauma may therefore represent an important group for early psychological assessment. However, childhood trauma should not be interpreted as determining whether an adolescent will engage in NSSI, and the present cross-sectional findings cannot establish that trauma exposure directly caused the reported self-injurious behavior. In practice, trauma history should be considered alongside current emotional distress, emotion-regulation difficulties, family support, and other NSSI-related indicators rather than being used as an isolated risk classification.

## **4.2 Indirect Association Through Emotional Impulsiveness**

Emotional impulsiveness showed the largest indirect association between childhood trauma and NSSI, accounting for 38.78% of the total association. Childhood trauma was positively associated with emotional impulsiveness, and emotional impulsiveness remained strongly associated with NSSI after childhood trauma, Internet addiction, gender, and age were considered. These findings support H2 and H3 and suggest that negative urgency–related emotional impulsiveness is an important proximal correlate of NSSI among adolescents with higher levels of childhood trauma.

Repeated exposure to threatening, unpredictable, or emotionally unresponsive environments has been associated with heightened emotional reactivity and reduced behavioral inhibition (McLaughlin et al. 2020; Shichiri et al. 2021; Weiss et al. 2023). Adolescents with these experiences may be more likely to rely on rapid, emotion-driven responses rather than delayed responding, cognitive reappraisal, or support

seeking when experiencing distress(Kim et al. 2021; Hashimoto et al. 2022; Jha et al. 2023; Zhang et al. 2023; Bo et al. 2024). Negative urgency may be particularly relevant to NSSI because it reflects the tendency to act rashly during intense negative affect, including anger, shame, frustration, and perceived loss of control(Silvers 2022; Liu et al. 2022a; Elliott et al. 2023; Weiss et al. 2023; Schreiber et al. 2025). Nevertheless, the present findings cannot determine whether childhood trauma preceded the development of negative urgency or whether negative urgency temporally preceded NSSI.

From a practical perspective, negative urgency may be more readily assessed than distal family experiences because it can be identified through brief validated questionnaires and clinical or school-based interviews. Schools and clinicians could pay particular attention to adolescents who repeatedly report acting rashly during intense distress, especially when these behaviors co-occur with trauma exposure, emotional dysregulation, Internet addiction, or NSSI indicators. Brief Negative Urgency screening could be incorporated into broader mental-health assessments to help determine whether further evaluation is warranted. Such screening should be treated as a referral signal rather than a diagnosis or proof that an adolescent will engage in NSSI. This approach provides a more realistic interpretation of emotional impulsiveness as a potential early-warning indicator while avoiding deterministic or causal conclusions.

## **4.3 Indirect Associations Through Internet Addiction and the Sequential Route**

Internet addiction showed a statistically significant indirect association between childhood trauma and NSSI, accounting for 11.04% of the total association. The sequential indirect association through emotional impulsiveness and Internet addiction was also significant but accounted for only 0.83% of the total association. These findings support H4 and H5 at the statistical level, while also indicating that the sequential route contributed substantially less than the indirect association through emotional impulsiveness alone.

Adolescents exposed to childhood trauma may use online activities for distraction, emotional avoidance, immediate reward, or compensatory social connection when adequate offline support is unavailable(Shi et al. 2020; Lieberz et al. 2021; De Coen et al. 2024; Gong and Zhou 2025). These functions may be especially relevant among adolescents with higher negative urgency because highly accessible online activities can provide rapid, although potentially temporary, relief from negative affect(Weinstein et al. 2016; Blasi et al. 2019), Internet addiction has also been associated with poorer offline adaptation, reduced face-to-face interaction, and greater emotional and behavioral difficulties(Cerniglia et al. 2017; Kumar et al. 2019; Tang et al. 2020). These explanations are theoretically plausible, but the present cross-sectional data cannot establish that childhood trauma led to emotional impulsiveness, which subsequently led to Internet addiction and then NSSI.

The small magnitude of the sequential indirect association is important for interpretation. It indicates that the sequence involving emotional impulsiveness and Internet addiction was statistically detectable in the large sample but was not the principal indirect association between childhood trauma and NSSI.

Moreover, Internet addiction remained independently and positively associated with NSSI in the separate moderation model after childhood trauma, emotional impulsiveness, physical activity, and their interaction were included ( $\beta = 0.050$ ,  $p = 0.029$ ), although the magnitude of this association was small. Internet addiction should therefore be interpreted as a relevant behavioral correlate rather than as an independent causal mechanism.

## 4.4 Moderating Role of Physical Activity

Physical activity significantly moderated the association between emotional impulsiveness and NSSI. The positive association was strongest at low physical activity ( $\beta = 0.552$ ), decreased at the mean level ( $\beta = 0.397$ ), and was weakest at high physical activity ( $\beta = 0.242$ ). These findings support H6 and indicate that higher physical activity was statistically associated with a weaker emotional impulsiveness–NSSI association. Importantly, however, emotional impulsiveness remained positively associated with NSSI at every examined physical activity level. Physical activity therefore did not eliminate the association between emotional impulsiveness and NSSI.

Several processes may help explain this moderation pattern. Physical activity has been associated with reduced tension, improved emotion regulation, increased perceived bodily control, positive reward experiences, and greater opportunities for offline social participation (van Woudenberg et al. 2020; Belcher et al. 2021; D’Cruz et al. 2024). These correlates may be relevant for adolescents with higher negative urgency, who may otherwise respond rapidly to intense negative affect. Physical activity is also practically accessible because it can be incorporated into physical education, after-school programs, student clubs, and community-based activities (Bangsbo et al. 2016; Mears and Jago 2016; Lubans et al. 2017; Parrish et al. 2020; Moon et al. 2026). Nevertheless, these possible explanations were not directly tested in the present study.

Although the interaction was statistically significant, its standardized coefficient was modest ( $\beta = -0.155$ ). Moreover, the study did not apply a clinically validated threshold or a minimal clinically important difference for changes in NSSI. The clinical meaningfulness of the observed moderation therefore cannot be determined from the present results. The finding should be interpreted as preliminary evidence of a potentially relevant association pattern rather than proof that physical activity has a clinically protective or therapeutic effect. Longitudinal and intervention studies incorporating objective physical activity measures are needed to determine whether increasing physical activity leads to meaningful reductions in NSSI risk among adolescents with elevated negative urgency.

## 4.5 Network Analysis as a Complement to Variable-Centered Results

The network analysis complemented the regression-based findings by describing conditional associations among specific dimensions and composite constructs. The strongest edge was observed between NSSI behavior and NSSI function, indicating substantial within-community connectivity between the two NSSI dimensions. Relatively strong associations were also observed among the three physical

activity indicators and among several childhood trauma dimensions. These findings describe conditional connectivity and should not be interpreted as evidence that one dimension caused another.

Among the between-community associations, emotional impulsiveness showed its strongest positive connection with NSSI behavior, followed by NSSI function. Several childhood trauma dimensions were positively connected with Internet addiction, particularly physical neglect, emotional neglect, and sexual abuse. Internet addiction showed negative conditional associations with all three physical activity indicators, while emotional impulsiveness also showed negative associations with exercise duration and frequency. These patterns provide a more differentiated description of the associations among emotional, behavioral, trauma-related, and lifestyle factors.

Internet addiction showed the highest bridge strength, whereas emotional impulsiveness showed the highest bridge expected influence. Both NSSI behavior and NSSI function also showed relatively high cross-community connectivity. In contrast, all three physical activity indicators showed negative bridge expected influence, consistent with their predominantly negative conditional associations with nodes from other communities.

These bridge rankings require cautious interpretation. Internet addiction and emotional impulsiveness were represented as single-node communities, whereas childhood trauma, NSSI, and physical activity contained multiple nodes. Differences in node aggregation and community size may therefore have influenced the bridge estimates. Moreover, separate stability coefficients for bridge indices were not available. Accordingly, the bridge findings should be interpreted as descriptive features of the present network rather than evidence that particular nodes are causal drivers or preferred intervention targets.

## **4.6 Theoretical and Practical Implications**

The present study contributes to the literature by integrating distal family adversity, proximal emotional and behavioral correlates, and a modifiable lifestyle factor within a single analytical framework. The variable-centered analyses quantified overall direct and indirect associations, whereas the network analysis described conditional connections among more specific dimensions. Together, these approaches suggest that adolescent NSSI is embedded within an interconnected set of family, emotional, behavioral, and lifestyle-related factors. However, the findings refine the description of these associations rather than establish a developmental or causal model.

From a practical perspective, the results support a multicomponent approach to school-based NSSI assessment. Trauma exposure, negative urgency, Internet addiction, and current NSSI indicators may be assessed together rather than treated as isolated factors. Adolescents reporting repeated emotion-driven impulsive behavior may require more detailed assessment of emotional distress, self-injury, family support, and Internet-use difficulties. Physical activity may be incorporated as an adjunct component of broader mental-health promotion because of its accessibility in school and community settings. It should not replace trauma-informed assessment, emotion-regulation support, clinical evaluation, or evidence-based treatment for adolescents who engage in NSSI. All screening indicators identified in this

study should be used to guide further evaluation and referral rather than to label adolescents or predict individual behavior.

## 5. Limitations and Future Directions

Several limitations should be considered when interpreting the findings. First, the study used a cross-sectional design, which prevents conclusions regarding temporal order and causality. Although the sequential mediation model was theoretically specified, it cannot demonstrate that childhood trauma preceded emotional impulsiveness or Internet addiction, or that these variables subsequently led to NSSI. Reciprocal associations among emotional impulsiveness, Internet addiction, physical activity, and NSSI are also possible. Similarly, the network edges represent undirected conditional associations and cannot establish directional relationships between nodes. Longitudinal and intensive repeated-measure designs are needed to examine temporal ordering and potential reciprocal processes.

Second, all variables were measured using self-report questionnaires. Childhood trauma reports may be affected by recall bias, whereas reports of NSSI and Internet addiction may be influenced by concealment or social desirability. Although Harman's single-factor test did not indicate substantial common method bias, this procedure cannot exclude all bias arising from the use of a single measurement method. Future studies should incorporate multiple sources of information, including clinical interviews, parent or teacher reports where appropriate, and behavioral or objective measures. In addition, convenience sampling limits generalizability. The sample contained relatively high proportions of rural, boarding, and non-only-child adolescents, and the findings may not generalize to adolescents from different educational, family, cultural, or socioeconomic contexts.

Third, physical activity was assessed using the self-reported PARS-3, which does not fully capture activity type, context, continuity, or objectively measured activity volume. The statistically significant interaction had a modest standardized coefficient, and no clinically validated threshold or minimal clinically important difference was available. Therefore, the clinical significance of the moderation result remains uncertain. Future studies should combine self-report data with accelerometers, wearable devices, or activity logs and use longitudinal or intervention designs to determine whether changes in physical activity are followed by meaningful changes in NSSI-related outcomes.

Fourth, the network combined dimension scores with composite scores. Although this strategy balanced theoretical specificity and model interpretability, different levels of node aggregation may have influenced centrality and bridge estimates. Emotional impulsiveness and Internet addiction were represented as single-node communities, whereas the other constructs contained multiple nodes, which may have affected comparisons of bridge indices. Furthermore, separate stability coefficients for bridge strength and bridge expected influence were not available. The bridge rankings should therefore be interpreted descriptively. Future research should compare alternative node specifications, conduct item-level or symptom-level networks where psychometrically appropriate, and directly assess the stability of bridge indices.

Finally, the moderation analysis was conducted separately from the sequential mediation analysis. The study therefore did not test whether physical activity moderated any specific indirect association between childhood trauma and NSSI. The findings support moderation of the emotional impulsiveness–NSSI association only and should not be interpreted as evidence of a complete moderated-mediation process. Future longitudinal research may examine conditional indirect associations while ensuring that the temporal ordering of variables is appropriately established.

## 6. Conclusion

In this cross-sectional study of 1,869 Chinese adolescents, childhood trauma was positively associated with NSSI. Emotional impulsiveness and Internet addiction showed significant indirect associations between childhood trauma and NSSI, with negative urgency–related emotional impulsiveness accounting for the largest indirect association. The sequential indirect association through emotional impulsiveness and Internet addiction was statistically significant but small in magnitude.

Physical activity moderated the emotional impulsiveness–NSSI association, with a weaker positive association observed at higher physical activity levels. However, emotional impulsiveness remained associated with NSSI at all examined physical activity levels, and the clinical significance of the interaction could not be established. The network analysis further examined conditional connections among childhood trauma, emotional impulsiveness, Internet addiction, physical activity, and NSSI.

Overall, the findings support the joint assessment of trauma exposure, negative urgency, Internet addiction, physical activity, and NSSI indicators in adolescent mental-health research and practice. Because the data were cross-sectional and self-reported, the results should not be interpreted as evidence of causal mechanisms, temporal progression, or clinically protective effects.

## Declarations

### Ethics approval and consent to participate

This study was reviewed and approved by the Biomedical Ethics Committee of Jishou University, China, with the approval number JSDX-2025-0071. All procedures involving human participants were conducted in accordance with the ethical standards of the Declaration of Helsinki and its later amendments, as well as relevant Chinese regulations concerning research involving human participants. All participants and their legal guardians provided informed consent before participation.

### Competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

### Author Contributions

W.X. conceived and designed the study, collected and analyzed the data, prepared the figures and tables,

and drafted the manuscript. J.Z. contributed to the interpretation of the findings and critically revised the manuscript. All authors reviewed and approved the final manuscript and agreed to be accountable for the work.

## **Funding**

This research received no external funding.

## **Acknowledgments**

The authors would like to thank all the students who participated in this study and the schools that supported the data collection.

## **Data Availability**

The de-identified dataset used in the present analyses, together with the network-analysis code, has been provided directly to the journal as confidential supplementary material for editorial and peer-review purposes. Because the dataset contains sensitive information from minor participants, it is not publicly accessible. Further access may be considered upon reasonable request, subject to appropriate ethics approval and data-use safeguards.

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## Figures

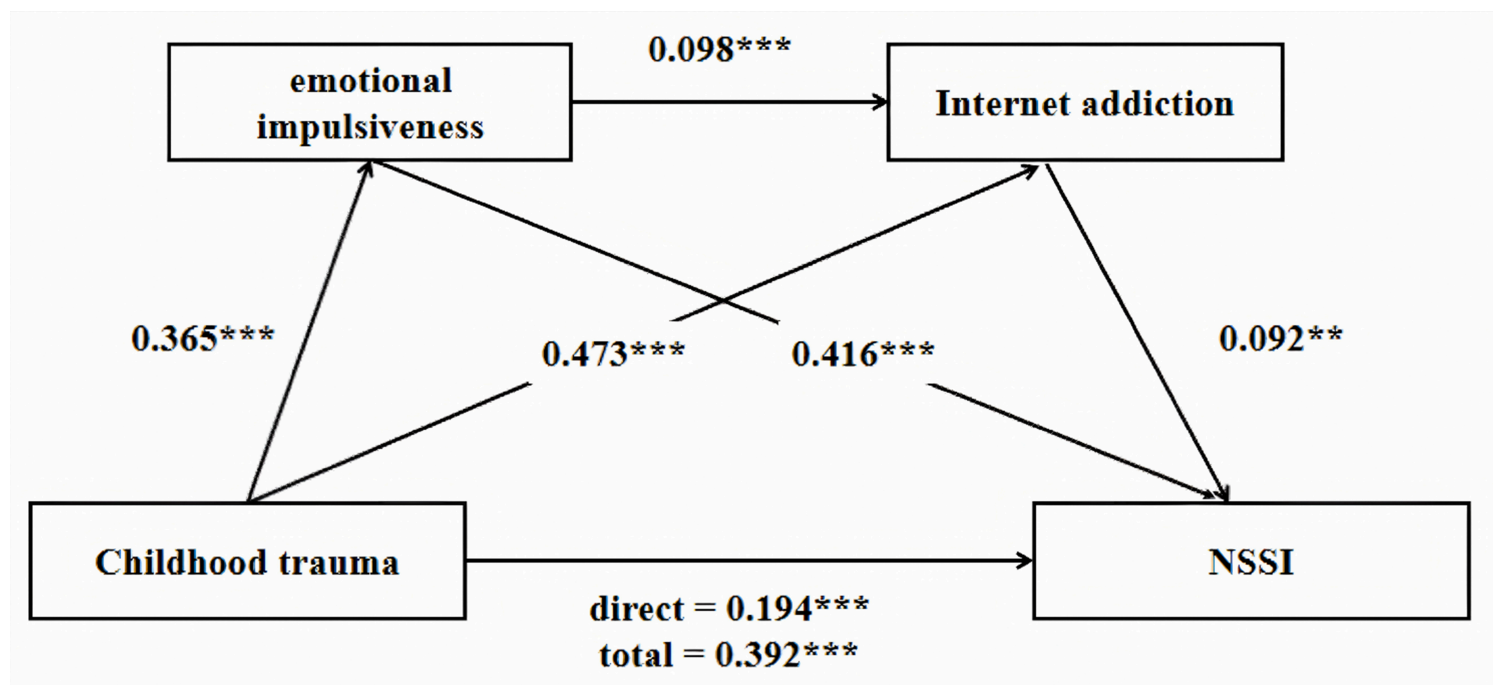


Figure 1

Cross-sectional sequential mediation model linking childhood trauma, emotional impulsiveness, Internet addiction, and NSSI.

**Note.** CTQ represents childhood trauma; IAT = Internet Addiction Test; NSSI = non-suicidal self-injury. Standardized coefficients are shown. Gender and age were controlled in the model. All path coefficients were statistically significant at  $p < 0.001$ . The arrows represent theoretically specified regression associations and do not indicate temporal or causal direction.

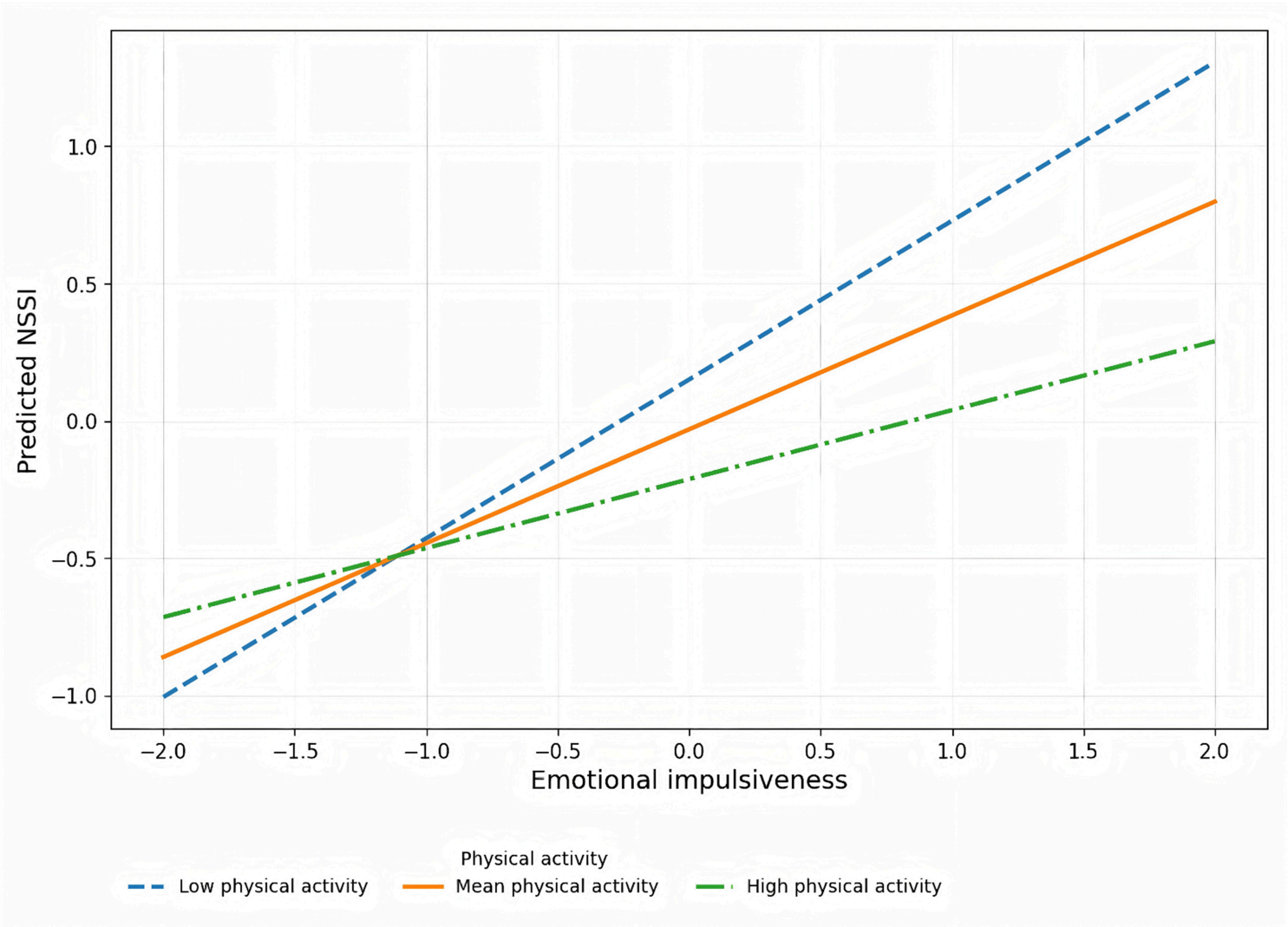


Figure 2

Association between emotional impulsiveness and NSSI at different levels of physical activity.

**Note.** NSSI = non-suicidal self-injury. Low, mean, and high physical activity represent one standard deviation below the mean, the mean, and one standard deviation above the mean, respectively.

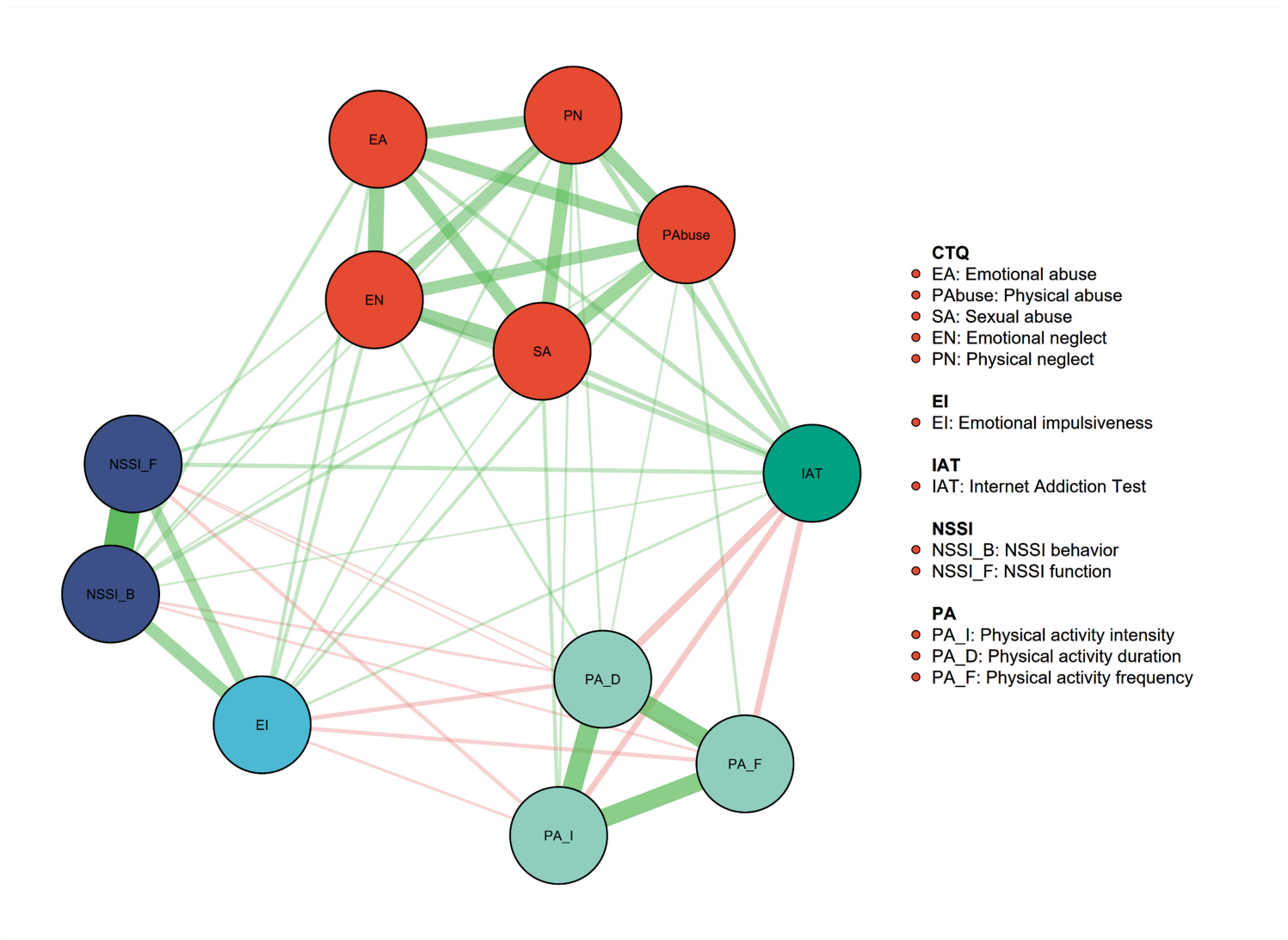


**Figure 3**

**The 12-node EBICglasso network of childhood trauma, emotional impulsiveness, Internet addiction, physical activity, and NSSI.**

**Note.** EA = emotional abuse; PAbuse = physical abuse; SA = sexual abuse; EN = emotional neglect; PN = physical neglect; EI = emotional impulsiveness; IAT = Internet Addiction Test; NSSI\_B = NSSI behavior; NSSI\_F = NSSI function; PA\_I = exercise intensity; PA\_D = exercise duration; PA\_F = exercise frequency. Green edges indicate positive conditional associations, and red edges indicate negative conditional associations. Thicker edges indicate stronger associations. Edge direction and node position do not represent temporal or causal relationships.

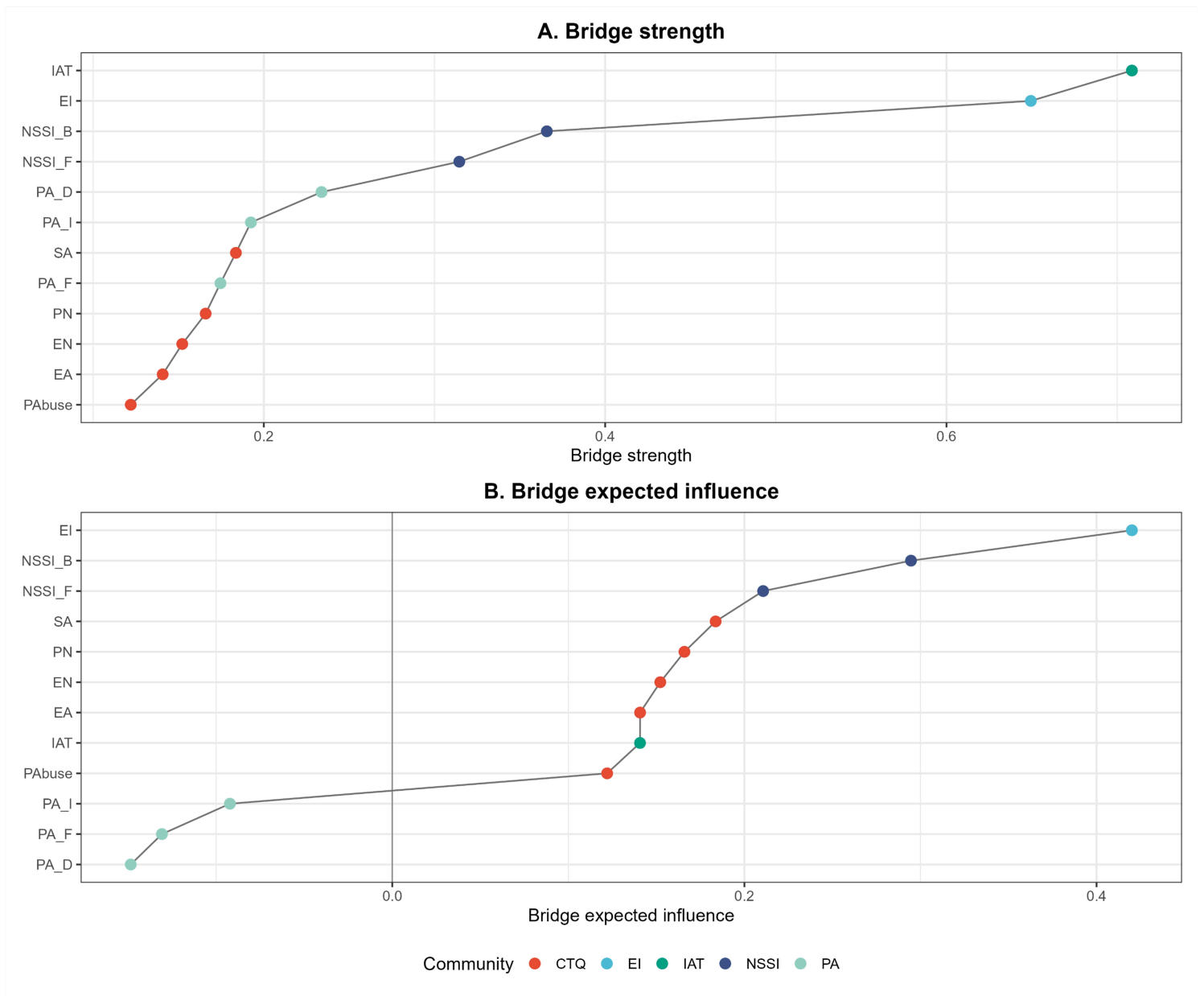


**Figure 4**

### Bridge strength and bridge expected influence in the 12-node network.

**Note.** Bridge strength reflects the absolute strength of a node's connections with nodes from other communities. Bridge expected influence reflects the sum of signed edge weights connecting a node with nodes from other communities. EI = emotional impulsiveness; IAT = Internet Addiction Test; NSSI = non-suicidal self-injury.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Supplementarylegends.docx](#)

- [FigureS1nodecentrality.png](#)
- [FigureS2nodepredictability.png](#)