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Effect of Emotion Self-Regulation Training on Risk-Taking Behaviors Among Adolescent Girls With Problematic Internet Use

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Abstract

Background

Adolescence is characterized by increased vulnerability to risk-taking behaviors, while emotion regulation represents a potentially modifiable psychological process that may influence such behaviors. This study examined whether emotion self-regulation training was associated with changes in risk-taking behaviors among adolescent girls with problematic internet use.

Methods

This cluster-randomized controlled trial was conducted among 188 female students aged 16–19 years with problematic internet use in Takestan, Iran. Six classes from three high schools were randomized to an intervention group (n=94) or a control group (n=94). The intervention consisted of eight weekly 60-minute group sessions based on Gross's process model of emotion regulation. Risk-taking behaviors were assessed at baseline (T0), immediately after the intervention (T1), and two months later (T2) using the Iranian Adolescent Risk-Taking Scale. Longitudinal linear mixed-effects models were used to examine group, time, and group-by-time effects, adjusting for educational level, economic status, birth rank, maternal education, paternal education, and number of children. For risky driving, the baseline risky-driving score was additionally included as a covariate.

Results

The group-by-time interaction for total risk-taking behaviors was not statistically significant (χ^2=5.39, df=2, P=.068), indicating no statistically significant differential change between the intervention and control groups over time. No significant group-by-time interactions were observed for risky driving (χ^2=0.49, df=1, P=.484), relationships with the opposite sex (χ^2=3.93,

df=2, P=.140), sexual relationships and behavior (χ^2=4.38, df=2, P=.112), smoking (χ^2=2.72, df=2, P=.256), alcohol (χ^2=0.31, df=2, P=.857), or drug-related behaviors (χ^2=0.34, df=2, P=.842). A statistically significant omnibus group-by-time interaction was observed for violence (χ^2=8.05, df=2, P=.018); however, adjusted pairwise comparisons did not identify statistically significant between-group differences at any individual assessment point.

Conclusions

Emotion self-regulation training did not demonstrate a statistically significant overall effect on risk-taking behaviors compared with the control condition. The significant omnibus interaction observed for violence was not supported by significant adjusted pairwise comparisons and should therefore be interpreted cautiously. Further cluster-randomized trials involving a larger number of randomized schools and classes are needed to provide more robust evidence.

Trial registration

The trial was prospectively registered in the Iranian Registry of Clinical Trials (IRCT20240514061786N1; registration date: 9 August 2024).

Keywords

Emotion regulation; risk-taking behavior; problematic internet use; adolescent girls; cluster-randomized controlled trial; adolescents

1. Introduction

1.1 Adolescence and risk-taking

Adolescence is a developmental period characterized by substantial changes in social, emotional, and cognitive functioning, during which engagement in risk-taking behaviors may increase. Risk-taking in adolescence has been linked to the interaction between heightened reward sensitivity and the still-developing capacity for cognitive control. From a dual-systems perspective, the socioemotional system becomes increasingly sensitive to rewarding and socially salient experiences during adolescence, whereas cognitive-control systems mature more gradually. This developmental imbalance may increase adolescents' susceptibility to risk-taking, particularly in situations involving emotional arousal, peer influence, or immediate rewards [1,2].

1.2 Risk-taking is multidimensional and relevant to public health

Adolescent risk-taking is multidimensional and may include substance use, risky sexual behavior, interpersonal aggression and violence, and other behaviors that can adversely affect physical, psychological, and social health. Importantly, these behaviors may cluster rather than occur in isolation. A large systematic review and meta-analysis involving more than 1.4 million adolescents found that frequent social media use was associated with several health-risk behaviors, including alcohol consumption, drug use, tobacco use, sexual risk behaviors, antisocial behavior, and multiple risk behaviors [3]. These findings highlight the importance of considering risk-taking as a broader behavioral construct rather than focusing exclusively on a single outcome.

1.3 Prevalence of problematic Internet use in Iranian adolescents

A recent systematic review and meta-analysis estimated that the prevalence of problematic Internet use (PIU) among Iranian adolescents following the COVID-19 pandemic was approximately 31% (95% CI, 17%–45%) [4]. However, prevalence estimates vary considerably across studies

depending on measurement tools and cut-off criteria. For instance, Shokri et al. reported that approximately one-quarter of Iranian high school students were at risk of Internet addiction using the Internet Addiction Test (IAT) [5]. In another large Iranian study, Akbari et al. identified five latent profiles of problematic social media use, ranging from low-risk to high-risk groups; the moderate-risk group represented 18.7% of the sample, while 14.9% were classified in the high-risk group [6]. These findings indicate that problematic digital-media use constitutes a substantial concern among Iranian adolescents, although estimates differ according to the construct assessed and the measurement approach used.

1.4 PIU and multidimensional risk behaviors

Problematic Internet use in adolescence has been linked to a range of adverse behavioral and health outcomes. Recent evidence indicates that emotion-regulation difficulties, problematic digital-media use, and negative consequences are consistently interconnected across several forms of digital-media engagement, including Internet use, video games, social networking, and messaging [7]. Longitudinal research further suggests that specific emotion-regulation difficulties may predict problematic video streaming over time. In a large adolescent sample, lack of emotional clarity remained the only significant longitudinal correlate of problematic video streaming after baseline problematic video-streaming symptoms were controlled [8]. Additionally, a recent neuroimaging preprint involving early adolescents found that greater social media use predicted increased gambling behavior, while greater screen time and social media use were associated with blunted striatal reward responses [9]. Because the latter study is a preprint rather than a peer-reviewed journal article, its findings should be interpreted as preliminary.

1.5 PIU, emotion dysregulation, and risk-related behavior

Emotional functioning appears to play an important role in problematic Internet use during adolescence. In a systematic review of 39 empirical studies, greater difficulties in regulating emotions among adolescents were consistently associated with more severe problematic technology use [10]. The same body of evidence indicated that anxiety, depressive symptoms, self-esteem, and behavioral problems tend to co-occur with both emotion dysregulation and problematic technology use [10]. Findings from longitudinal research further suggest that the association between problematic Internet use and emotional difficulties is unlikely to be unidirectional; rather, the two domains may influence each other over time, with maladaptive emotion-regulation processes emerging as possible explanatory mechanisms [11].

This overlap is directly relevant to risk-taking because difficulties in regulating emotions may reduce adolescents' capacity to pause, evaluate potential consequences, and select adaptive responses during periods of heightened emotional arousal. Emotion-regulation training therefore represents a promising and potentially modifiable intervention target. Evidence from adolescent trials indicates that such training can influence some health-risk behaviors [12]. Nevertheless, it remains unclear whether structured emotion-regulation training can alter broader patterns of risk-taking specifically among adolescents with problematic Internet use [10,11].

1.6 Emotion regulation as a theoretically plausible intervention target

Emotion regulation refers to the processes through which individuals influence which emotions they experience, when those emotions arise, and how they are experienced and expressed [13]. Gross's process model situates regulation at several points along the emotion-generative timeline—situation selection, situation modification, attentional deployment, cognitive change,

and response modulation—thereby providing a theoretical basis for teaching adolescents strategies that can shape emotional responses before they contribute to maladaptive behavioral choices [13].

Developmental evidence reinforces the relevance of these processes to adolescent adjustment. A meta-analysis and narrative review of 212 studies involving more than 80,000 participants found that maladaptive emotion-regulation and coping patterns were associated with higher levels of psychopathology, whereas adaptive regulatory processes were generally associated with better adjustment [14].

1.7 What previous intervention studies have shown—and where they were limited

Evidence directly testing emotion-regulation interventions for adolescent risk behaviors is promising but remains incomplete. Houck et al. conducted a trial with 420 early adolescents aged 12–14 years who presented with emotional or behavioral symptoms. Their 12-session emotion-regulation program was followed by lower engagement in sexual activity and in some other risk behaviors, such as fighting, immediately after the intervention [12]. The authors nevertheless pointed to several constraints, including recruitment from a single geographic area, a relatively narrow age range, enrollment of adolescents referred for emotional or behavioral concerns, reliance on self-report, and the relatively brief initial follow-up window [12].

The one-year follow-up provided stronger temporal evidence. Adolescents in the emotion-regulation condition were less likely to transition to vaginal sexual activity, and violence-related behaviors were lower [15]. Effects, however, did not carry over consistently to substance-use outcomes, and the authors again noted constraints related to the narrow age range, single

geographic region, self-report measures, and limited applicability to adolescents without identified mental health symptoms [15].

A later trial that tested an emotion-regulation program for adolescents at risk for sexual behaviors likewise reported methodological constraints [16]. Outcomes were self-reported, the sample was characterized by emotional and behavioral health symptoms, the intervention was evaluated using a within-school rather than individual-level randomized design, and the geographic setting was restricted. These features narrowed the generalizability of the findings and left open whether the effects would hold in broader adolescent populations or across other risk-taking domains [16].

Evidence is not uniformly encouraging. In a randomized controlled micro-trial with 108 adolescents who had elevated externalizing problems, emotion-regulation training increased self-reported use of adaptive regulation strategies, yet externalizing problems declined more in the control condition [17]. The authors emphasized that improvement in a proposed mechanism does not necessarily produce improvement in the targeted behavioral outcome, underscoring the need to test intervention effects directly on clinically and behaviorally meaningful outcomes rather than assuming that better emotion regulation will automatically produce behavioral change [17].

Finally, a systematic review of school-based interventions aimed at improving emotional regulation identified important methodological weaknesses across the field. Among the most frequent limitations were inadequate follow-up assessment and the absence of formal sample-size calculations; the review also noted substantial variability in intervention methods and outcome assessment [18]. Only a minority of studies specifically evaluated risky behaviors, further emphasizing the need for well-designed trials that examine behavioral outcomes directly [18].

1.8 The specific research gap addressed by the present study

Taken together, the available evidence points to several notable gaps. First, prior emotion-regulation trials have mostly enrolled adolescents selected on the basis of emotional or behavioral symptoms or specific risk profiles [12,15,16]. Although one recent trial has examined a meaning- and emotion-regulation-based program among adolescents with problematic interactive media use [19], the evidence base remains limited, and no study to our knowledge has tested a stand-alone emotion self-regulation program against a broad, multidimensional spectrum of risk-taking specifically among adolescents with problematic Internet use.

Second, several interventions have concentrated on a single risk outcome, most often sexual behavior, rather than capturing a wider range of adolescent risk-taking domains [15,16]. Third, earlier work has often depended on self-reported outcomes and on samples that were narrow or geographically confined, which limits generalizability [12,15,16]. Fourth, some studies have relied on immediate or relatively short-term assessments, leaving uncertainty about whether behavioral differences endure beyond the intervention period [12,17]. Fifth, systematic reviews of school-based emotion-regulation programs indicate that rigorous methodological features, including formal sample-size planning and adequate follow-up, have not been applied consistently across the literature [18].

The present study was designed to address several of these limitations. We focused specifically on adolescent girls with problematic Internet use, rather than recruiting adolescents solely on the basis of general emotional or behavioral symptoms. We used a cluster-randomized controlled design at the class level, enrolled 188 adolescents from three schools, and assessed outcomes at baseline, immediately after the eight-session intervention, and two months later. Rather than restricting the

evaluation to a single behavior, we examined overall risk-taking as well as seven domains: risky driving, relationships with the opposite sex, sexual relationships and behavior, violence, smoking, alcohol use, and drug/substance use. This multidimensional approach allowed us to evaluate whether emotion self-regulation training was associated with a broader pattern of behavioral change among adolescents with problematic Internet use.

2. Methods

2.1 Study design and setting

This study was a cluster-randomized controlled trial conducted during the 2024–2025 academic year in Takestan, Iran. The unit of randomization was the school class rather than the individual student. Class-level randomization was selected primarily to reduce potential contamination between students assigned to the intervention and control conditions because students within the same class had regular contact during the school day.

The study was registered prospectively in the Iranian Registry of Clinical Trials (IRCT20240514061786N1; registration date: 9 August 2024). Ethical approval was obtained from Qazvin University of Medical Sciences (IR.QUMS.REC.1403.18). The trial was reported with consideration of the CONSORT extension for cluster-randomized trials, including explicit reporting of the unit of randomization, allocation process, intervention, outcomes, and analytical approach [20].

2.2 Participants

Participants were female high-school students aged 16–19 years. Three girls' high schools participated in the study, from which six classes were included and randomized. Three classes were allocated to the intervention group and three classes to the control group.

A total of 188 students participated in the trial, with 94 students allocated to each study arm. Eligibility was based on the prespecified study criteria and included female high-school students within the specified age range who met the study's criteria for problematic Internet use according to the screening procedure and provided the required consent/assent.

Because the intervention was delivered in a school setting and randomization occurred at the class level, all eligible students within participating classes were analyzed according to the allocation of their respective class. Thus, the individual student was the unit of observation, whereas the class was the unit of randomization.

2.3 Sample-size determination

The initial sample-size calculation was performed at the individual-participant level and indicated a requirement of 84 participants per study arm. Allowing approximately 10% for potential attrition resulted in a target of 94 participants per arm, giving a total planned sample of 188 students.

Because the study used cluster randomization, this individual-level calculation did not explicitly incorporate an intraclass correlation coefficient (ICC), the design effect, variation in cluster size, or the number of randomized clusters. Accordingly, the calculated sample size should not be interpreted as a cluster-adjusted power calculation.

This distinction is important because only six classes were randomized. In cluster-randomized trials with a small number of clusters, conventional individual-level analyses may have limited precision and may require small-sample methods to provide reliable inference [21,22]. Simulation studies have specifically shown that the performance of analytical methods depends strongly on the number of randomized clusters and that appropriate small-sample corrections or cluster-level approaches may be required when the number of clusters is small [21,22].

Therefore, the individual-level sample-size calculation and the small number of randomized classes are recognized as important methodological limitations of the trial and should be considered when interpreting the precision and statistical significance of the intervention effects.

2.4 Randomization and allocation concealment

Randomization was performed at the class level. An independent statistician generated the allocation sequence using permuted blocks of size two. Sequentially numbered, opaque, sealed envelopes were used to conceal the allocation sequence.

After eligible classes had been identified and enrolled, a second independent researcher opened the envelopes and implemented the allocation. Three classes were allocated to the emotion self-regulation intervention and three classes to the control condition.

Because the intervention was delivered within the classroom setting, participants and the intervention facilitator could not be blinded to group assignment. Outcome assessment and statistical analysis were conducted independently of intervention delivery.

2.5 Intervention

The intervention consisted of eight weekly 60-minute group sessions based on Gross's process model of emotion regulation [13].

The program was designed to teach students to recognize and identify emotional states, identify emotional triggers, regulate attention during emotionally challenging situations, apply cognitive change/reappraisal strategies, and select adaptive response-modulation strategies. Sessions progressively moved from recognition of emotional processes to application of regulation skills in situations involving interpersonal conflict, social pressure, frustration, and other circumstances that may increase vulnerability to impulsive or risky responses.

The intervention emphasized practical skill acquisition rather than simple provision of information. Students were encouraged to recognize the sequence linking situations, emotional responses, cognitions, and behavioral impulses and to practice alternative regulatory responses.

The intervention was delivered over eight consecutive weeks, with each session lasting approximately 60 minutes.

2.6 Control condition

Students assigned to the control condition did not receive the emotion self-regulation program during the study period and continued their usual educational activities. Educational materials related to emotion self-regulation were provided to students in the control condition after completion of the study.

This inactive-control design permitted comparison of longitudinal changes between students receiving the specific emotion self-regulation program and those continuing their usual educational activities.

2.7 Measures

Young's Internet Addiction Test

Problematic Internet use was assessed using Young's Internet Addiction Test (IAT), a 20-item instrument developed to assess the extent to which Internet use is associated with functional impairment and problematic patterns of use [24,25].

The IAT was used in this study to characterize problematic Internet use and to establish eligibility according to the study protocol. It was not used as a diagnostic instrument for a formal psychiatric diagnosis of Internet-use disorder or social-media addiction.

Iranian Adolescent Risk-Taking Scale

The primary behavioral outcome was assessed using the Iranian Adolescent Risk-Taking Scale (IARS), developed and psychometrically evaluated specifically for Iranian adolescents [26].

The IARS contains 38 items and assesses multiple domains of adolescent risk-taking behavior, including:

1. risky driving;
2. relationships with the opposite sex;
3. sexual relationships and behavior;

4. violence;
5. smoking;
6. alcohol use; and
7. drug/substance use.

The total IARS score was prespecified as the primary behavioral outcome, whereas the seven domain scores were examined as secondary outcomes.

The IARS was therefore treated as an established Iranian instrument with previously reported psychometric evaluation rather than as a newly developed or newly validated measure in the present study [26].

2.8 Assessment schedule

Outcomes were assessed at three time points:

- **T0:** baseline, before the intervention;
- **T1:** immediately after completion of the eight-session intervention;
- **T2:** two months after completion of the intervention.

The longitudinal assessment structure permitted examination of changes over time and, critically, whether the pattern of change differed between the intervention and control groups.

2.9 Statistical analysis

Statistical analyses were conducted using R statistical software. Linear mixed-effects models were fitted using the **nlme** package, and the **car** package was used for relevant inferential procedures and model diagnostics.

For each outcome, a longitudinal linear mixed-effects model was fitted including group, time, and the group-by-time interaction. The principal test of intervention effectiveness was the **group-by-time interaction**, because this term evaluates whether the trajectory of change over time differed between the intervention and control groups. Main effects of time were interpreted as changes over time across groups and were not considered evidence of an intervention effect in the absence of a corresponding group-by-time interaction.

Models were adjusted for educational level, economic status, birth rank, maternal education, paternal education, and number of children. The risky-driving model additionally included the baseline risky-driving score as a covariate.

Wald χ^2 statistics were used to evaluate model terms, and all tests were two-sided. A P value $<.05$ was considered statistically significant.

Residual diagnostics and covariance-structure considerations were examined during model development.

Because randomization occurred at the class level and only six classes were randomized, the limited number of clusters was explicitly considered when interpreting the inferential results. Methodological research indicates that cluster-randomized trials with small numbers of clusters may have limited statistical power and that the performance of conventional analytical approaches can be sensitive to the number of clusters and the methods used to estimate uncertainty [21,22].

The available analysis output did not document the use of a Kenward–Roger, Satterthwaite, or other explicit small-sample correction. Therefore, no such correction is claimed in this manuscript.

Accordingly, the inferential findings, particularly borderline P values and findings involving secondary outcomes, were interpreted cautiously in light of the small number of randomized classes [21,22].

Adjusted pairwise comparisons between intervention and control groups at each assessment point were also examined. These comparisons were used to determine whether an omnibus group-by-time finding corresponded to a specific between-group difference at baseline, immediately after the intervention, or at follow-up.

For the risky-driving outcome, baseline risky-driving score was included as a covariate; therefore, adjusted between-group comparisons were reported for the post-intervention and follow-up assessments rather than treating the baseline score as an additional between-group outcome comparison.

The reported partial eta-squared values correspond to the supplied model output and are presented as model-based effect-size estimates. They were not independently recalculated from the raw data and should therefore not be interpreted as independently derived standardized treatment effects.

3. Results

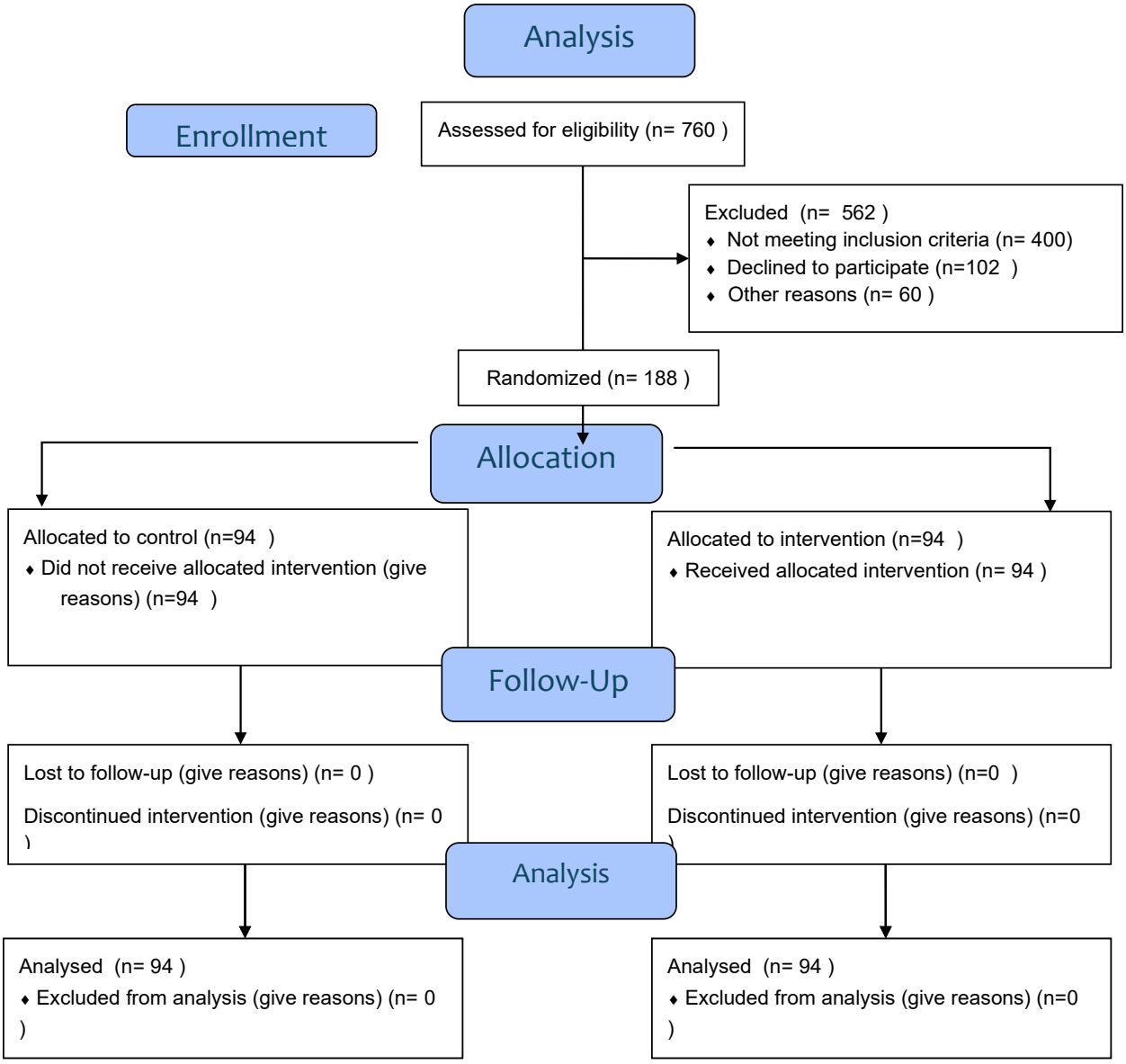
3.1 Participant flow and allocation

A total of 188 female high-school students from three girls' high schools in Takestan, Iran, participated in the trial. Six classes were randomized at the class level, with three classes allocated

to the intervention group and three classes to the control group. Ninety-four students were allocated to each group. All 188 participants were included in the longitudinal analyses, with 94 participants in each group at baseline, immediately after the intervention, and the two-month follow-up. No loss to follow-up was reported.

The participant and cluster flow through the trial is presented in Figure 1.

Figure 1. CONSORT flow diagram of the cluster-randomized controlled trial



Risk-taking behavior was assessed at baseline (T0), immediately after the intervention (T1), and at the two-month follow-up (T2). Longitudinal changes were examined using linear mixed-effects models, with adjustment for educational level, economic status, birth rank, maternal education,

paternal education, and number of children. For risky driving, the baseline risky-driving score was additionally included as a covariate.

3.2 Total risk-taking behavior

The descriptive scores for total risk-taking behavior were similar between the two groups at all assessment points. In the control group, the mean total risk-taking score was 74.02 ± 21.37 at baseline, 74.01 ± 21.20 immediately after the intervention, and 73.97 ± 20.87 at the two-month follow-up. Corresponding values in the intervention group were 74.43 ± 17.70, 73.53 ± 16.91, and 73.35 ± 16.84, respectively (Table 1).

In the adjusted mixed-effects model, the main effect of time was statistically significant, $\chi^2(2)=6.26$, P=.044, whereas the group-by-time interaction, representing the differential change between the intervention and control groups, was not statistically significant, $\chi^2(2)=5.39$, P=.068. The main effect of group was also not significant, $\chi^2(1)=0.00$, P=.961. None of the other covariates showed a statistically significant association with total risk-taking behavior. The partial η^2 for the group-by-time interaction was 0.0143 (Table 2).

Adjusted pairwise comparisons showed no significant difference between the control and intervention groups at baseline (estimate=−0.4962560, SE=2.812702, df=178, t=−0.1764339, P=.8601536), immediately after the intervention (estimate=0.3867227, SE=2.812702, df=178, t=0.1374915, P=.8907977), or at the two-month follow-up (estimate=0.5250206, SE=2.812702, df=178, t=0.1866606, P=.8521394) (Table 3).

3.3 Risky driving

The mean risky-driving scores were 13.50 ± 5.80 in the control group and 16.59 ± 4.40 in the intervention group at T1, and 13.67 ± 5.75 and 16.60 ± 4.50, respectively, at T2.

Because the baseline risky-driving score was included as a covariate in the model, the adjusted analysis focused on post-intervention and follow-up outcomes. The baseline risky-driving score was strongly associated with subsequent risky-driving scores, $\chi^2(1)=3119.86$, $P<.001$, with a partial η^2 of 0.9525. Economic status was also significantly associated with risky driving, $\chi^2(1)=8.42$, $P=.004$. However, neither the main effect of group, $\chi^2(1)=1.37$, $P=.242$, nor the group-by-time interaction, $\chi^2(1)=0.49$, $P=.484$, was statistically significant. The time effect was also not significant, $\chi^2(1)=0.63$, $P=.428$.

Adjusted pairwise comparisons showed no significant between-group difference at T1 (estimate=0.1332656, SE=0.2149849, df=177, t=0.6198836, P=.5361316) or T2 (estimate=0.2928401, SE=0.2149849, df=177, t=1.3621426, P=.1748838) (Tables 2 and 3).

3.4 Relationships with the opposite sex

The mean scores for relationships with the opposite sex were 10.41 ± 4.32, 10.35 ± 4.31, and 10.45 ± 4.27 in the control group at T0, T1, and T2, respectively. The corresponding values in the intervention group were 10.94 ± 4.08, 10.90 ± 4.04, and 10.82 ± 3.99.

The adjusted mixed-effects model showed no significant group-by-time interaction, $\chi^2(2)=3.93$, $P=.140$. The main effects of group and time were also not significant ($\chi^2(1)=0.67$, $P=.412$ and $\chi^2(2)=1.16$, $P=.559$, respectively). Maternal education was significantly associated with this outcome, $\chi^2(2)=7.18$, $P=.028$. The partial η^2 for the group-by-time interaction was 0.0105.

Adjusted pairwise comparisons revealed no significant between-group differences at T0 (estimate=−0.5293499, SE=0.6004901, df=178, t=−0.8815298, P=.3792199), T1 (estimate=−0.5612648, SE=0.6004901, df=178, t=−0.9346779, P=.3512206), or T2 (estimate=−0.3804138, SE=0.6004901, df=178, t=−0.6335054, P=.5272168).

3.5 Sexual relationships and behavior

The mean scores for sexual relationships and behavior in the control group were 7.94 ± 4.14 at T0, 7.94 ± 4.14 at T1, and 8.09 ± 4.11 at T2. The corresponding intervention-group scores were 7.82 ± 4.13, 7.76 ± 4.06, and 7.80 ± 3.91.

The group-by-time interaction was not statistically significant, $\chi^2(2)=4.38$, P=.112. Neither the group effect, $\chi^2(1)=0.12$, P=.726, nor the time effect, $\chi^2(2)=5.63$, P=.060, reached statistical significance. Economic status was significantly associated with this outcome, $\chi^2(1)=4.10$, P=.043. The partial η^2 for the group-by-time interaction was 0.0116.

Adjusted pairwise comparisons showed no significant between-group differences at T0 (estimate=0.1283894, SE=0.5918630, df=178, t=0.2169242, P=.8285159), T1 (estimate=0.1922192, SE=0.5918630, df=178, t=0.3247697, P=.7457367), or T2 (estimate=0.2986022, SE=0.5918630, df=178, t=0.5045123, P=.6145254).

3.6 Violence

The mean violence scores were 9.53 ± 4.73, 9.56 ± 4.71, and 9.64 ± 4.62 in the control group at T0, T1, and T2, respectively. In the intervention group, the corresponding values were 9.43 ± 4.77, 9.20 ± 4.39, and 9.28 ± 4.36.

The adjusted mixed-effects model showed a statistically significant group-by-time interaction, $\chi^2(2)=8.05$, P=.018, with a partial η^2 of 0.0212. Maternal education was also significantly associated with violence scores, $\chi^2(2)=6.43$, P=.040. However, the main effects of group, $\chi^2(1)=0.12$, P=.727, and time, $\chi^2(2)=3.75$, P=.154, were not significant.

Importantly, the adjusted pairwise comparisons did not show statistically significant differences between the groups at T0 (estimate=0.06087248, SE=0.6642627, df=178, t=0.09163917, P=.9270878), T1 (estimate=0.31619163, SE=0.6642627, df=178, t=0.47600389, P=.6346553), or T2 (estimate=0.31619163, SE=0.6642627, df=178, t=0.47600389, P=.6346553). Therefore, the statistically significant omnibus group-by-time interaction should be interpreted cautiously and does not by itself establish a significant between-group difference at a specific assessment point.

3.7 Smoking addiction

The mean smoking-addiction scores in the control group were 8.43 ± 3.87 at T0, 8.44 ± 3.86 at T1, and 8.36 ± 3.69 at T2. Corresponding values in the intervention group were 7.78 ± 3.15, 7.71 ± 3.08, and 7.77 ± 3.01.

The group-by-time interaction was not statistically significant, $\chi^2(2)=2.72$, P=.256. Neither the group effect, $\chi^2(1)=1.73$, P=.188, nor the time effect, $\chi^2(2)=0.97$, P=.614, was significant. Maternal education showed a significant association with smoking addiction, $\chi^2(2)=9.85$, P=.007. The partial η^2 for the group-by-time interaction was 0.0073.

Adjusted pairwise comparisons showed no significant differences between the groups at T0 (estimate=0.6401745, SE=0.4940053, df=178, t=1.295886, P=.1966926), T1

(estimate=0.7146426, SE=0.4940053, df=178, t=1.446629, P=.1497594), or T2 (estimate=0.5869830, SE=0.4940053, df=178, t=1.188212, P=.2363329).

3.8 Alcohol addiction

The control group's mean alcohol-addiction scores were 11.19 ± 5.71 at T0, 11.18 ± 5.68 at T1, and 11.05 ± 5.38 at T2. The corresponding intervention-group scores were 9.91 ± 4.00, 9.85 ± 3.91, and 9.79 ± 3.92.

The group-by-time interaction was not statistically significant, $\chi^2(2)=0.31$, P=.857. The main effects of group and time were also not significant ($\chi^2(1)=3.34$, P=.067 and $\chi^2(2)=4.98$, P=.083, respectively). Birth rank was significantly associated with alcohol addiction, $\chi^2(1)=5.18$, P=.023. The partial η^2 for the group-by-time interaction was 0.0008.

Adjusted pairwise comparisons revealed no significant between-group differences at T0 (estimate=1.249367, SE=0.6945269, df=178, t=1.798875, P=.07373263), T1 (estimate=1.302558, SE=0.6945269, df=178, t=1.875461, P=.06236678), or T2 (estimate=1.238729, SE=0.6945269, df=178, t=1.783557, P=.07619946).

3.9 Drug addiction

The mean drug-addiction scores were 13.03 ± 7.34, 13.04 ± 7.26, and 12.71 ± 6.59 in the control group at T0, T1, and T2, respectively. In the intervention group, the corresponding values were 11.56 ± 4.90, 11.52 ± 4.82, and 11.31 ± 4.65.

The adjusted model showed a statistically significant main effect of time, $\chi^2(2)=10.42$, P=.005. However, the group-by-time interaction was not statistically significant, $\chi^2(2)=0.34$, P=.842, and

the main effect of group was also not significant, $\chi^2(1)=2.84$, P=.092. The partial η^2 for time was 0.0272, whereas the partial η^2 for the group-by-time interaction was 0.0009.

Adjusted pairwise comparisons showed no significant between-group differences at T0 (estimate=1.464560, SE=0.8739521, df=178, t=1.675789, P=.09553512), T1 (estimate=1.517751, SE=0.8739521, df=178, t=1.736652, P=.08417859), or T2 (estimate=1.400730, SE=0.8739521, df=178, t=1.602754, P=.11076211).

Overall, the longitudinal mixed-effects analyses did not demonstrate a statistically significant differential change in total risk-taking behavior between the intervention and control groups. Likewise, no statistically significant group-by-time interaction was observed for risky driving, relationships with the opposite sex, sexual relationships and behavior, smoking addiction, alcohol addiction, or drug addiction. Although the group-by-time interaction for violence was statistically significant, the corresponding adjusted pairwise comparisons at each assessment point were not significant; therefore, this finding should be interpreted cautiously.

Table 1. Descriptive statistics of risk-taking behavior scores by study group and assessment time

Outcome	Time	Control (0)	Intervention (1)
Total risk-taking	T0	74.02 ± 21.37[a]	74.43 ± 17.70[a]
	T1	74.01 ± 21.20[a]	73.53 ± 16.91[a]
	T2	73.97 ± 20.87[a]	73.35 ± 16.84[a]
Risky driving	T1	13.50 ± 5.80[a]	16.59 ± 4.40[a]
	T2	13.67 ± 5.75[a]	16.60 ± 4.50[a]

Relationships with the opposite sex	T0	10.41 ± 4.32[a]	10.94 ± 4.08[a]
	T1	10.35 ± 4.31[a]	10.90 ± 4.04[a]
	T2	10.45 ± 4.27[a]	10.82 ± 3.99[a]
Sexual relationships and behavior	T0	7.94 ± 4.14[a]	7.82 ± 4.13[a]
	T1	7.94 ± 4.14[a]	7.76 ± 4.06[a]
	T2	8.09 ± 4.11[a]	7.80 ± 3.91[a]
Violence	T0	9.53 ± 4.73[a]	9.43 ± 4.77[a]
	T1	9.56 ± 4.71[a]	9.20 ± 4.39[a]
	T2	9.64 ± 4.62[a]	9.28 ± 4.36[a]
Smoking addiction	T0	8.43 ± 3.87[a]	7.78 ± 3.15[a]
	T1	8.44 ± 3.86[a]	7.71 ± 3.08[a]
	T2	8.36 ± 3.69[a]	7.77 ± 3.01[a]
Alcohol addiction	T0	11.19 ± 5.71[a]	9.91 ± 4.00[a]
	T1	11.18 ± 5.68[a]	9.85 ± 3.91[a]
	T2	11.05 ± 5.38[a]	9.79 ± 3.92[a]
Drug addiction	T0	13.03 ± 7.34[a]	11.56 ± 4.90[a]
	T1	13.04 ± 7.26[a]	11.52 ± 4.82[a]
	T2	12.71 ± 6.59[a]	11.31 ± 4.65[a]

Note: Values are presented as mean ± SD. Group 0 = control; Group 1 = intervention. Inferential analyses were adjusted for educational level, economic status, birth rank, maternal education, and paternal education; number of children was also included as a covariate. For risky driving, the baseline risky-driving score was additionally included as a covariate.

Table 2. Adjusted linear mixed-effects model results for risk-taking behavior outcomes

Outcome	Parameter	χ^2 (df)	P value	Partial η^2
Total	(Intercept)	8.09 (1)	.004	—
	Level.num	0.48 (1)	.488	.0030
	Number_of_child	0.07 (1)	.797	.0073
	Economic_situaion	0.10 (1)	.753	.0023
	Birth_rank	1.60 (1)	.206	.0126
	Mother_education	3.14 (2)	.208	.0164
	Father_education	0.36 (2)	.835	.0020
	Group	0.00 (1)	.961	.0000
	Time	6.26 (2)	.044	.0165
	Group × Time	5.39 (2)	.068	.0143
Dangerous driving	(Intercept)	0.23 (1)	.633	—
	Dangerous_driving_T0	3119.86 (1)	<.001	.9525
	Number_of_child	0.00 (1)	.973	.0102
	Economic_situaion	8.42 (1)	.004	.0502
	Birth_rank	2.77 (1)	.096	.0107
	Mother_education	0.73 (2)	.694	.0001
	Father_education	3.70 (2)	.157	.0185
	Level.num	1.68 (1)	.195	.0102

	Group	1.37 (1)	.242	.0077
	Time	0.63 (1)	.428	.0034
	Group × Time	0.49 (1)	.484	.0026
Relationships with the opposite sex	(Intercept)	2.66 (1)	.103	—
	Number_of_child	2.04 (1)	.153	.0005
	Economic_situaion	0.25 (1)	.620	.0041
	Birth_rank	0.85 (1)	.356	.0116
	Mother_education	7.18 (2)	.028	.0489
	Father_education	1.38 (2)	.501	.0079
	Level.num	0.08 (1)	.776	.0003
	Group	0.67 (1)	.412	.0038
	Time	1.16 (2)	.559	.0031
	Group × Time	3.93 (2)	.140	.0105
Sexual relationships and behavior	(Intercept)	3.33 (1)	.068	—
	Number_of_child	0.07 (1)	.794	.0005
	Economic_situaion	4.10 (1)	.043	.0257
	Birth_rank	0.79 (1)	.373	.0004
	Mother_education	2.49 (2)	.289	.0191
	Father_education	2.33 (2)	.312	.0123
	Level.num	0.16 (1)	.685	.0009
	Group	0.12 (1)	.726	.0007
	Time	5.63 (2)	.060	.0149

	Group × Time	4.38 (2)	.112	.0116
Violence	(Intercept)	0.11 (1)	.739	—
	Number_of_child	0.01 (1)	.936	.0000
	Economic_situaion	1.73 (1)	.188	.0090
	Birth_rank	0.04 (1)	.833	.0012
	Mother_education	6.43 (2)	.040	.0373
	Father_education	0.97 (2)	.615	.0074
	Level.num	2.10 (1)	.147	.0120
	Group	0.12 (1)	.727	.0007
	Time	3.75 (2)	.154	.0100
	Group × Time	8.05 (2)	.018	.0212
Smoking addiction	(Intercept)	4.72 (1)	.030	—
	Number_of_child	1.57 (1)	.211	.0191
	Economic_situaion	0.01 (1)	.928	.0000
	Birth_rank	1.71 (1)	.191	.0081
	Mother_education	9.85 (2)	.007	.0621
	Father_education	0.35 (2)	.839	.0018
	Level.num	0.14 (1)	.707	.0011
	Group	1.73 (1)	.188	.0096
	Time	0.97 (2)	.614	.0026
	Group × Time	2.72 (2)	.256	.0073
Alcohol addiction	(Intercept)	2.06 (1)	.151	—
	Number_of_child	0.54 (1)	.462	.0002

	Economic_situaion	1.12 (1)	.290	.0045
	Birth_rank	5.18 (1)	.023	.0340
	Mother_education	4.58 (2)	.101	.0300
	Father_education	1.37 (2)	.503	.0073
	Level.num	0.69 (1)	.406	.0047
	Group	3.34 (1)	.067	.0184
	Time	4.98 (2)	.083	.0132
	Group × Time	0.31 (2)	.857	.0008
Drug addiction	(Intercept)	4.30 (1)	.038	—
	Number_of_child	0.01 (1)	.933	.0016
	Economic_situaion	1.45 (1)	.228	.0061
	Birth_rank	3.45 (1)	.063	.0183
	Mother_education	4.13 (2)	.127	.0254
	Father_education	2.09 (2)	.351	.0116
	Level.num	0.01 (1)	.932	.0002
	Group	2.84 (1)	.092	.0157
	Time	10.42 (2)	.005	.0272
	Group × Time	0.34 (2)	.842	.0009

Note: Results were adjusted for educational level, economic status, birth rank, maternal education, and paternal education; number of children was also included as a covariate. For dangerous driving, the baseline dangerous-driving score was additionally included as a covariate. Partial η^2 values are reported as provided by the statistical output.

Table 3. Adjusted pairwise comparisons between control and intervention groups at each assessment time

Outcome	Group comparison	Time	Estimate	SE	df	t-ratio	P value
Total	0 − 1	T0	−0.4962560	2.812702	178	−0.1764339	.8601536
	0 − 1	T1	0.3867227	2.812702	178	0.1374915	.8907977
	0 − 1	T2	0.5250206	2.812702	178	0.1866606	.8521394
Dangerous driving	0 − 1	T1	0.1332656	0.2149849	177	0.6198836	.5361316
	0 − 1	T2	0.2928401	0.2149849	177	1.3621426	.1748838
Relationships with the opposite sex	0 − 1	T0	−0.5293499	0.6004901	178	−0.8815298	.3792199
	0 − 1	T1	−0.5612648	0.6004901	178	−0.9346779	.3512206
	0 − 1	T2	−0.3804138	0.6004901	178	−0.6335054	.5272168

Sexual relationships and behavior	0 − 1	T0	0.1283894	0.5918630	178	0.2169242	.8285159
	0 − 1	T1	0.1922192	0.5918630	178	0.3247697	.7457367
	0 − 1	T2	0.2986022	0.5918630	178	0.5045123	.6145254
Violence	0 − 1	T0	0.06087248	0.6642627	178	0.09163917	.9270878
	0 − 1	T1	0.31619163	0.6642627	178	0.47600389	.6346553
	0 − 1	T2	0.31619163	0.6642627	178	0.47600389	.6346553
Smoking addiction	0 − 1	T0	0.6401745	0.4940053	178	1.295886	.1966926
	0 − 1	T1	0.7146426	0.4940053	178	1.446629	.1497594
	0 − 1	T2	0.5869830	0.4940053	178	1.188212	.2363329
Alcohol addiction	0 − 1	T0	1.249367	0.6945269	178	1.798875	.07373263
	0 − 1	T1	1.302558	0.6945269	178	1.875461	.06236678

	0 − 1	T2	1.238729	0.6945269	178	1.783557	.07619946
Drug addiction	0 − 1	T0	1.464560	0.8739521	178	1.675789	.09553512
	0 − 1	T1	1.517751	0.8739521	178	1.736652	.08417859
	0 − 1	T2	1.400730	0.8739521	178	1.602754	.11076211

Note: Results were adjusted for educational level, economic status, birth rank, maternal education, and paternal education; number of children was also included as a covariate. For dangerous driving, the baseline dangerous-driving score was additionally included as a covariate. For dangerous driving, T0 was not included in the adjusted pairwise comparisons because the baseline dangerous-driving score was entered as a covariate. Group 0 = control; Group 1 = intervention; therefore, estimates represent control minus intervention.

4. Discussion

This cluster-randomized controlled trial evaluated whether an eight-session emotion self-regulation intervention could reduce risk-taking behaviours among adolescent girls with problematic internet use. The principal finding was that the intervention did not produce a statistically significant group-by-time difference in total risk-taking behaviour. Similarly, no significant group-by-time interaction was observed for risky driving, relationships with the opposite sex, sexual relationships and behaviour, smoking, alcohol use, or drug/substance use. Although the omnibus group-by-time interaction for violence was statistically significant, none of

the adjusted between-group comparisons at the individual assessment points was statistically significant. Taken together, these findings do not provide sufficient evidence that the intervention reduced overall risk-taking behaviour.

These findings are important because they challenge a relatively simple assumption that improving emotion regulation will necessarily produce immediate reductions in observable risk-taking. Emotion regulation is relevant to adolescent adjustment, but adolescent risk-taking is a multidetermined behaviour shaped by developmental, social, motivational, and contextual processes. Developmental models emphasize the interaction between heightened sensitivity to reward and still-maturing self-regulatory capacities during adolescence, while social-affective development may further increase the importance of peer and social contexts during this period [1,2,28].

4.1 Why did improvement in emotion-regulation skills not translate into lower overall risk-taking?

Gross's process model conceptualizes emotion regulation as a set of processes through which individuals influence the emotions they experience, when they experience them, and how they are expressed. These processes include attentional deployment, cognitive change, and response modulation [13]. However, risk-taking behaviour may occur in situations characterized by immediate reward, social evaluation, and peer influence. Experimental evidence indicates that the presence of peers can increase adolescents' risk-taking and risky decision-making, suggesting that behavioural choices may be particularly sensitive to social context during adolescence [2,29].

Thus, possessing or learning an emotion-regulation skill does not necessarily mean that the adolescent will use that skill when confronted with immediate social reward, peer approval, provocation, or other highly salient behavioural cues. The distinction between emotional self-regulation and direct regulation of risk-taking behaviour may therefore be important. An intervention may improve emotional awareness or regulatory skills without sufficiently modifying the social contingencies, perceived rewards, or behavioural habits that maintain risk-taking.

This interpretation is partly consistent with previous intervention research but also highlights an important difference between the present study and much of the existing evidence. Meta-analytic studies have found that psychological interventions can improve emotion regulation or reduce emotion dysregulation in youth. Moltrecht et al., for example, reported small effects for improvement in emotion regulation and moderate effects for reductions in emotion dysregulation, although substantial heterogeneity was observed across interventions, populations, and outcome measures [30]. Eadeh et al. similarly found significant intervention effects on emotion-regulation outcomes among adolescents, while emphasizing methodological variability and the need to identify moderators of treatment effects [31]. These findings are therefore broadly consistent with the possibility that emotion-regulation interventions can be beneficial, but they do not establish that improvements in emotion regulation necessarily generalize to broad behavioural outcomes such as risk-taking.

The discrepancy may also reflect the content and duration of the present intervention. The programme consisted of eight weekly sessions and primarily targeted emotion self-regulation. Sustained changes in complex risk-taking behaviours may require repeated practice in real-world situations and intervention components that directly address behavioural decision-making,

perceived norms, peer pressure, and risk appraisal. Accordingly, the absence of a significant effect on risk-taking should not necessarily be interpreted as evidence that emotion-regulation training is ineffective; rather, it may indicate that emotion regulation alone is insufficient to modify a broad set of adolescent risk behaviours.

4.2 Consistency and inconsistency with previous evidence

The present findings both converge with and diverge from previous evidence. They converge with meta-analytic research indicating that emotion-regulation-focused psychological interventions can improve emotion-regulation outcomes among young people [30,31]. However, they diverge from the expectation that such improvements will necessarily translate into reductions in complex, observable risk-taking behaviours. This distinction is important because the outcome targeted in the present trial was not emotion regulation itself but a multidimensional behavioural construct encompassing several forms of risk-taking.

The findings can also be contrasted with evidence from broader school-based social and emotional learning programmes. Durlak et al. reported beneficial effects of universal school-based social and emotional learning interventions across multiple developmental outcomes [32]. However, such programmes generally address a broader range of competencies, including social awareness, interpersonal skills, self-management, and responsible decision-making. The narrower focus of the present intervention may therefore partly explain why its effects did not extend clearly to overall risk-taking behaviour.

At the same time, the present findings should not be interpreted as evidence that problematic internet or social-media use is unrelated to adolescent risk-taking. Previous meta-analytic evidence

has identified positive associations between social-media use and several risk behaviours. Vannucci et al. found small-to-moderate positive associations between social-media use and general risky behaviours, substance use, and risky sexual behaviours among adolescents [33]. More recently, Purba et al. reported predominantly adverse associations between social-media use and several adolescent health-risk behaviours, including alcohol, drug and tobacco use, sexual risk behaviours, antisocial behaviour, and multiple risk behaviours [3]. Importantly, however, these literatures are predominantly observational, and Purba et al. emphasized that evidence for causality remains limited [3]. Thus, the association between problematic online engagement and risk-taking does not imply that modifying emotion regulation alone should eliminate these behaviours.

4.3 The importance of peer influence

Peer influence provides another plausible explanation for the absence of a significant overall intervention effect. Adolescents frequently make risk-related decisions within social environments, and experimental evidence has shown that adolescents may take greater risks in the presence of peers than when making decisions alone [29]. Peer contagion processes may further reinforce problematic behaviours within adolescent groups, particularly when peer interactions provide social rewards for risk-taking or other maladaptive behaviours [34].

This issue is particularly relevant to the present cluster-randomized design. Class-level randomization was used to reduce the risk of contamination between intervention and control students; however, students remained embedded within their ordinary peer environments. An intervention directed primarily at individual emotional regulation may therefore have had limited influence on peer norms, social reinforcement, and the immediate interpersonal context in which risk-related decisions occur.

Future interventions may benefit from combining emotion-regulation training with peer-resistance skills, social problem-solving, communication training, and strategies for managing online and offline peer pressure. Such multimodal approaches may more directly address the social mechanisms through which adolescent risk-taking is maintained.

4.4 Problematic internet use as a contextual rather than singular mechanism

The inclusion of adolescents with problematic internet use was theoretically relevant because online environments may interact with social, emotional, and behavioural processes associated with risk-taking. Nevertheless, problematic internet use should not be interpreted as a single causal pathway leading to risk behaviour.

The broader social-media literature suggests that the relationship between online engagement and risk-taking is heterogeneous. Vannucci et al. found positive associations between social-media use and several risk behaviours, but their meta-analysis included predominantly cross-sectional studies, limiting conclusions about directionality [33]. Purba et al. likewise found predominantly adverse associations between social-media use and health-risk behaviours, while emphasizing substantial limitations in causal inference, including confounding and reverse causation [3]. These findings provide contextual support for considering problematic internet use as part of a broader behavioural ecology rather than as an isolated causal mechanism.

Accordingly, adolescents with problematic internet use may simultaneously experience emotional difficulties, peer-related pressures, and other contextual vulnerabilities, while online environments may also reinforce existing behavioural tendencies. An intervention focused primarily on emotion regulation may therefore fail to address other mechanisms that sustain problematic internet use

and associated risk behaviours. This possibility may help explain why a theoretically relevant individual-level intervention did not produce a significant reduction in the broader risk-taking outcome.

4.5 Interpretation of the violence finding

The significant group-by-time interaction observed for violence requires cautious interpretation. At first glance, this result could suggest that the intervention influenced violence-related behaviour. However, none of the adjusted intervention-control comparisons at baseline, post-intervention, or follow-up was statistically significant. The most appropriate interpretation is therefore that the omnibus interaction detected a statistically different pattern of change over time between groups, whereas the point-specific adjusted comparisons did not identify a significant between-group difference at any individual assessment point.

Given the number of outcomes examined and the small number of randomized clusters, the violence finding should be considered exploratory rather than confirmatory. This caution is particularly important because trials with very small numbers of randomized clusters may be vulnerable to unstable inference and increased concerns regarding type-I error when conventional analytical approaches are used without appropriate small-sample corrections [21,22]. Therefore, the violence result should not be presented as definitive evidence that emotion self-regulation training reduced violence.

Nevertheless, the finding may generate a useful hypothesis for future research. Violence-related behaviour can occur in situations involving emotional arousal, frustration, and interpersonal conflict, which are contexts in which emotion-regulation processes may plausibly be relevant.

Future adequately powered cluster-randomized trials should therefore examine whether emotion-regulation interventions have domain-specific effects on aggression or violence, preferably while directly measuring changes in emotion-regulation processes.

4.6 The importance of baseline risky driving

The very strong association between baseline risky-driving scores and subsequent risky-driving outcomes is notable and is consistent with longitudinal evidence indicating that risky-driving behaviour can show substantial temporal stability during adolescence. In a three-month prospective study of adolescents, baseline risky driving predicted risky driving at follow-up, and risky-driving patterns were stable in approximately 80% of adolescents during the study period [35].

This pattern has important implications for interpreting intervention effects because adolescents who already demonstrate relatively established risky-driving tendencies may require interventions that directly address behavioural decision-making, risk perception, perceived norms, and established behavioural habits in addition to emotion regulation.

The strong baseline association also supports the decision to adjust subsequent risky-driving analyses for the baseline risky-driving score. In randomized trials in which the same continuous outcome is measured at baseline and follow-up, incorporating baseline information into the analysis can improve the precision of follow-up comparisons and appropriately account for pre-existing outcome levels [36].

In the present study, the absence of a significant group-by-time interaction for risky driving after adjustment for baseline risky-driving score therefore provides no evidence of a differential intervention effect on this outcome.

4.7 Socioeconomic and parental characteristics

Several covariates were associated with specific risk-taking domains. Economic status was associated with risky driving and sexual relationships/behaviour, maternal education was associated with relationships with the opposite sex, violence, and smoking, and birth rank was associated with alcohol use. These findings should not be interpreted causally because the present trial was not designed to estimate causal effects of socioeconomic or parental characteristics.

Nevertheless, the pattern is consistent with the broader view that adolescent risk-taking is embedded within social and family contexts rather than determined solely by individual psychological processes. Parental and socioeconomic characteristics may shape the social, monitoring, and resource environments in which adolescents make behavioural decisions. These factors therefore warrant consideration in future multilevel interventions.

Importantly, the present analyses did not formally test socioeconomic status, parental education, or other covariates as moderators or mediators of intervention effects. Future studies should therefore examine these variables prospectively as potential moderators rather than assuming that the associations observed in the present analyses represent moderation or mediation.

4.8 Why the cluster design matters

A major strength of the present study was class-level randomization, which reduced the risk of contamination between intervention and control students. However, the same design created an important statistical limitation: only six classes were randomized. Thus, although the individual-level sample comprised 188 students, the number of independent randomized units was only six.

This distinction is important for interpretation. Methodological research indicates that cluster-randomized trials with very small numbers of clusters can have low statistical power and may produce unstable inference when standard analytical approaches are used without appropriate corrections [21,22]. Leyrat et al. found that several commonly used approaches performed poorly when fewer than 20 clusters were randomized and recommended small-sample corrections or variance-weighted cluster-level approaches for continuous outcomes [21]. Kahan et al. similarly demonstrated increased type-I error concerns in cluster-randomized trials with small numbers of clusters [22].

Accordingly, the present mixed-effects findings should be interpreted cautiously and should not be regarded as definitive evidence either for or against the intervention. The six-cluster design is particularly relevant when interpreting the non-significant primary group-by-time interaction because limited numbers of clusters reduce the precision and power of cluster-level intervention comparisons.

Future cluster-randomized trials should include substantially more randomized classes or schools and should incorporate the intraclass correlation coefficient, expected cluster size, and design effect into the sample-size calculation. Where the number of clusters remains small, small-sample corrections or cluster-level analytical approaches should be prespecified and justified [21,22].

4.9 Overall interpretation

Overall, the present trial does not provide evidence that eight sessions of emotion self-regulation training produced a statistically significant reduction in total risk-taking behaviour among adolescent girls with problematic internet use. The absence of significant effects across most behavioural domains, together with the exploratory nature of the violence finding and the very small number of randomized clusters, argues against interpreting the intervention as an established strategy for reducing adolescent risk-taking.

At the same time, the findings should not be interpreted as evidence that emotion regulation is irrelevant to adolescent risk behaviour. Previous meta-analytic evidence indicates that emotion-regulation-focused interventions can improve emotion-regulation outcomes in youth, whereas the present trial suggests that such improvements may not automatically generalize to broad, socially embedded risk-taking behaviours [30,31]. Future interventions may therefore need to integrate emotion regulation with direct behavioural, peer-focused, and decision-making components and should be evaluated in adequately powered cluster-randomized designs with a larger number of independent clusters.

4.10 Strengths

Several strengths should be noted. First, the study used a cluster-randomized controlled design rather than a simple pre-post comparison, allowing the intervention to be evaluated against a concurrent control condition. Second, randomization was performed at the class level to reduce the likelihood of contamination between intervention and control students, which is an important consideration for school-based behavioural interventions. Third, outcomes were assessed at

baseline, immediately after the intervention, and again at two months, allowing both immediate changes and short-term maintenance of behavioural outcomes to be examined. Fourth, the study evaluated both an overall risk-taking score and seven distinct behavioural domains, providing a more comprehensive assessment than reliance on a single global outcome. Fifth, the longitudinal mixed-effects analyses accounted for repeated observations and incorporated prespecified demographic and socioeconomic covariates, while the risky-driving analysis additionally adjusted for the baseline risky-driving score. Finally, the study was prospectively registered and reported according to the methodological principles applicable to cluster-randomized trials.

4.11 Limitations

Several limitations should be considered when interpreting the findings. The most important limitation was the small number of randomized clusters. Only six classes from three schools were randomized, meaning that the effective number of independent experimental units was substantially smaller than the total number of participating students. Consequently, statistical power for detecting cluster-level intervention effects was limited, and the precision and stability of conventional mixed-effects inference may be reduced. This limitation is particularly relevant to the interpretation of the non-significant group-by-time interaction for the primary outcome. Although the analysis accounted for the clustered and repeated-measures structure, the sample-size planning did not explicitly incorporate an intraclass correlation coefficient (ICC) or a design effect. Current guidance for cluster-randomized trials emphasizes the importance of accounting for clustering in both sample-size determination and analysis [20-22].

Second, the study was conducted among female students aged 16–19 years recruited from three girls' high schools in one Iranian city. The findings therefore may not be generalizable to male

adolescents, younger or older age groups, adolescents outside school settings, or students living in other geographic, cultural, or socioeconomic contexts. This limitation is particularly relevant because risk-taking behaviours and their social determinants may vary across developmental stages and settings.

Third, participants and intervention facilitators could not be blinded to group allocation because the nature of a behavioural educational intervention made masking impractical. Awareness of treatment assignment may therefore have introduced expectancy or performance effects. Although efforts were made to maintain blinding of outcome assessment and statistical analysis where feasible, complete elimination of bias related to treatment awareness cannot be assumed. This limitation should be considered when interpreting behavioural outcomes based on participant-reported measures.

Fourth, risk-taking behaviours were assessed using self-report instruments. Self-reported behavioural outcomes may be affected by recall error, misunderstanding of items, and social-desirability bias, particularly for sensitive behaviours such as sexual behaviour, substance use, and violence. Although validated instruments were used, objective or independently verified behavioural measures were not available for most outcomes.

Fifth, the intervention primarily targeted individual emotion self-regulation and did not directly modify the broader social ecology in which adolescent risk-taking occurs. Peer norms and peer reinforcement, parental monitoring, family processes, online social environments, perceived behavioural norms, and opportunities to engage in risky behaviours were not directly targeted. Therefore, the absence of a broad intervention effect may reflect the multidimensional nature of adolescent risk-taking rather than the irrelevance of emotion regulation itself.

Sixth, the study examined multiple behavioural domains and multiple assessment points. Although the analyses were prespecified within the overall study framework, the number of statistical comparisons increases the possibility of chance findings. This consideration is particularly important for the statistically significant omnibus group-by-time interaction observed for violence, because none of the corresponding adjusted pairwise comparisons at the individual assessment points was statistically significant. The violence finding should therefore be interpreted as exploratory and hypothesis-generating rather than as confirmatory evidence of treatment efficacy.

Finally, the follow-up period was limited to two months after the intervention. Although this design permitted assessment of short-term maintenance, it cannot establish whether any behavioural changes would persist over longer periods. Larger trials with more randomized clusters, longer follow-up, and interventions that integrate emotion regulation with peer, family, behavioural decision-making, and digital-environment components are therefore warranted.

5. Conclusion

In this cluster-randomized controlled trial of adolescent girls with problematic internet use, eight weekly sessions of emotion self-regulation training did not provide sufficient evidence of a statistically significant reduction in overall risk-taking behaviour compared with the control condition. No significant group-by-time interaction was observed for risky driving, relationships with the opposite sex, sexual relationships and behaviour, smoking, alcohol use, or drug/substance use.

Although the omnibus group-by-time interaction for violence was statistically significant, the corresponding adjusted pairwise comparisons at the individual assessment points were not

statistically significant. This finding should therefore be considered exploratory rather than evidence of a confirmed treatment effect.

The findings suggest that emotion self-regulation is a theoretically relevant but potentially insufficient stand-alone target for modifying complex adolescent risk-taking behaviours. The results should not be interpreted as evidence that emotion regulation has no relevance to risk-taking; rather, they suggest that improving emotion-regulation skills alone may not be sufficient to modify behaviours that are also shaped by peer influence, social reinforcement, behavioural decision-making, and contextual factors.

Future research should evaluate multimodal interventions that combine emotion-regulation training with peer-resistance and social problem-solving skills, behavioural decision-making and risk-appraisal strategies, family involvement, and components addressing online and offline social environments. Most importantly, future cluster-randomized trials should recruit substantially more independent classes or schools, incorporate ICC-based sample-size calculations and appropriate design effects, and prespecify suitable small-sample statistical corrections when the number of clusters is limited [20-22]. Longer follow-up periods would also be valuable for determining whether any behavioural effects are sustained.

Declarations

Ethics and Guidelines

This study was approved by the Ethics Committee of Qazvin University of Medical Sciences (QUMS), Qazvin, Iran, in accordance with the guidelines and regulations set forth by the Declaration of Helsinki and the National Ethical Guidelines for Biomedical Research in Iran issued

by the Ministry of Health and Medical Education. The protocol approval number is IR.QUMS.REC.1403.18. Informed consent and, where applicable, parental/guardian consent and adolescent assent were obtained in accordance with the approved study protocol. Informed consent and, where applicable, parental/guardian informed consent and adolescent assent were obtained in accordance with the approved study protocol.

Trial registration

The trial was prospectively registered in the Iranian Registry of Clinical Trials under registration number IRCT20240514061786N1 on 9 August 2024.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available because of ethical and participant-confidentiality considerations. Data may be available from the corresponding author upon reasonable request and subject to applicable institutional and ethical restrictions.

Competing interests

The authors declare no competing interests.

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Authors' contributions

Author Contributions

Neda Rahmani: Conceptualization, Methodology, Investigation, Data curation, Writing – original draft.

Ahad Alizadeh: Formal analysis, Statistical analysis, Data analysis, Validation.

Mahmoud Bahramkhani: Conceptualization, Supervision, Psychological consultation, Methodology, Review and editing.

Solmaz Heidarifard: Conceptualization, Methodology, Supervision, Project administration, Writing – review and editing, Corresponding author.

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