

Intervention Adherence And Cognitive Processing In Adolescents: A Secondary Analysis Of A School-Based Randomized Controlled Trial

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Abstract

Background: Participant adherence is an important component of intervention implementation and may influence the extent of exposure to behavioural programmes. While randomized controlled trials commonly evaluate intervention efficacy, secondary analyses examining the relationship between adherence and outcomes provide valuable evidence regarding intervention dose and participant engagement. **Objective:** To examine whether adherence to a structured mind–body intervention was associated with changes in intuitive and rational cognitive processing among adolescents participating in a school-based randomized controlled trial. **Methods:** This secondary analysis included participants allocated to the intervention arm of a randomized controlled trial conducted among adolescents aged 10–15 years. Attendance records were maintained throughout the intervention period. Based on overall attendance, participants were classified into a high-adherence group ($\geq 90\%$ attendance; $n = 26$) and a low-adherence group ($< 90\%$ attendance; $n = 12$). Change scores were calculated by subtracting baseline scores from post-intervention scores. Between-group comparisons were performed using the Mann–Whitney U test. **Results:** Attendance ranged from 73% to 99% of scheduled sessions. Twenty-six participants (68.4%) demonstrated high adherence, while twelve (31.6%) had attendance below 90%. Participants with high adherence showed significantly greater improvements in intuitive processing than those with lower adherence ($U = 96.50$, $p = 0.028$). Similarly, rational processing improved significantly more among participants with high adherence ($U = 102.00$, $p = 0.041$). **Conclusion:** Greater adherence to the intervention was associated with superior cognitive outcomes. These findings suggest that greater intervention exposure and consistent participation may be associated with greater improvements in cognitive processing among adolescents and highlight the importance of strategies that promote consistent engagement in school-based interventions.

Keywords: adherence, intervention fidelity, cognitive processing, intuitive processing, rational processing, adolescents, school-based intervention.

1. Introduction

Adherence is an important component of implementation fidelity and may influence the extent to which participants are exposed to the intended components of an intervention (Carroll et al., 2007). Greater adherence provides greater exposure to the intervention and may allow participants to repeatedly engage with and practise the processes targeted by the programme. Conversely, inconsistent participation results in lower exposure and may be associated with smaller changes. Examining the relationship between adherence and outcomes therefore provides an opportunity to understand whether variation in intervention exposure is accompanied by variation in treatment response.

During adolescence, cognitive abilities continue to develop through changes in executive functions, attentional control, decision-making, and self-regulation (Blakemore & Choudhury, 2006). Structured interventions incorporating attentional training, movement, breathing regulation, and relaxation have been proposed to influence these cognitive and self-regulatory processes, including sustained attention and cognitive flexibility (Diamond & Ling, 2016). However, improvements observed following such interventions may not be uniform across participants, and the extent to which differences in intervention exposure contribute to this variability remains insufficiently explored.

Most intervention studies primarily examine differences between intervention and control groups to determine whether an intervention is effective. While this approach establishes overall efficacy, it provides less information about whether participants who engage more consistently derive greater benefit than those with lower levels of engagement (Dane & Schneider, 1998). Examining adherence–outcome relationships can therefore provide complementary information about intervention response and may help clarify whether a greater degree of exposure is associated with larger changes in targeted outcomes (Durlak & DuPre, 2011). This question is particularly relevant in school-based interventions, where participation can be influenced by academic schedules, school activities,

absenteeism, and other competing demands.

The parent randomized controlled trial demonstrated changes in cognitive processing following participation in the intervention. However, the primary analysis did not address whether the magnitude of these changes varied according to the degree of participant adherence. The present secondary analysis was therefore undertaken among participants in the intervention arm to examine whether higher levels of adherence were associated with greater improvements in intuitive and rational cognitive processing. By examining adherence within the intervention group, the study sought to extend the findings of the parent trial and provide insight into the relationship between intervention exposure and cognitive response among adolescents.

2. Methods

2.1 Study Design

This study is a secondary analysis of data obtained from the intervention arm of a school-based randomized controlled trial that evaluated the effects of a structured mind–body intervention on cognitive processing among adolescents. While the primary trial examined differences between the intervention and control groups, the present analysis focused exclusively on participants who received the intervention to determine whether the degree of intervention adherence was associated with cognitive outcomes. Specifically, the study investigated the relationship between attendance and changes in intuitive and rational cognitive processing following completion of the intervention.

2.2 Study Setting and Participants

The parent randomized controlled trial was conducted in two schools in Kerala, India, among adolescents aged 10–15 years. Participants were recruited after obtaining institutional ethical approval, permission from the respective school authorities, written informed consent from parents or legal guardians, and assent from the students.

Thirty-eight participants allocated to the intervention arm who completed both baseline and post-intervention assessments were included in the present secondary analysis. Participants with incomplete outcome data or who withdrew from the intervention before completion were excluded. Baseline demographic and cognitive characteristics of the intervention cohort have been reported in the primary trial.

2.3 Intervention

Participants underwent a structured school-based intervention delivered over a period of 22 weeks during regular school days. The programme consisted of 176 supervised sessions conducted by trained instructors following a standardized intervention protocol. Intervention delivery was consistent across both participating schools to ensure uniform implementation and intervention fidelity.

2.4 Outcome Measures

The primary outcomes of the present analysis were changes in intuitive and rational cognitive processing measured before and after the intervention. Intuitive and rational decision-making performance was assessed using the Rapid Response Task–Youth (RRT–Youth) (Sourabh et al., 2025), while cognitive processing style was evaluated using the Rational–Experiential Inventory (REI) (Epstein et al., 1996). Change scores for each outcome were calculated by subtracting baseline scores from post-intervention scores, with positive values indicating improvement following the intervention.

2.5 Measurement of Intervention Adherence

Intervention adherence was determined using attendance records maintained throughout the study. Attendance was recorded for every scheduled session by the intervention instructors using standardized attendance registers. Each participant was expected to attend a total of 176 intervention sessions during the study period.

Attendance percentage was calculated for each participant based on the proportion of scheduled sessions attended. Attendance ranged from 73% to 99% across participants. Based on overall attendance, participants were classified into two predefined adherence categories: high adherence (attendance $\geq 90\%$) and low adherence (attendance $< 90\%$). Of the 38 participants included in the intervention group, 26 (68.4%) demonstrated high adherence, while 12 (31.6%) were classified as having low adherence. These adherence categories formed the basis for all subsequent analyses.

2.6 Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics (Version XX; IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participant characteristics and attendance patterns.

Baseline demographic characteristics and pre-intervention cognitive scores were compared between the high-adherence and low-adherence groups to determine baseline comparability prior to the intervention. Continuous variables were analysed using the Mann–Whitney U test, while categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate.

Change scores were calculated for each cognitive outcome by subtracting baseline scores from post-intervention scores. Because the change-score data were not normally distributed, differences between the high-adherence and low-adherence groups were examined using the Mann–Whitney U test. All statistical tests were two-tailed, and a p-value <0.05 was considered statistically significant.

3. Results

3.1 Attendance Profile

Attendance across participants ranged from 73% to 99% of scheduled sessions, with a median attendance of 94% (IQR: 85.25–96%). Twenty-five participants (65.8%) attended at least 90% of scheduled sessions, while 13 participants (34.2%) had attendance below 90%.

Table 1. Attendance profile of intervention participants

Attendance category	n	%
High adherence (≥90%)	26	68.4
Low adherence (<90%)	12	31.6
Total	38	100.0

3.2 Association Between Adherence and Cognitive Outcomes

Participants with high adherence demonstrated significantly greater improvements in both intuitive and rational cognitive processing compared with participants who attended fewer than 90% of intervention sessions.

Table 2. Comparison of change scores according to adherence

Outcome	High adherence (n=26)	Low adherence (n=12)	U	p
Intuitive processing change	Insert Median (Q1–Q3)	Insert Median (Q1–Q3)	96.50	0.028*
Rational processing change	Insert Median (Q1–Q3)	Insert Median (Q1–Q3)	102.00	0.041*

*Significant at $p < 0.05$.

Participants with attendance of at least 90% exhibited significantly greater gains in intuitive processing than those with lower attendance ($U = 96.50$, $p = 0.028$). A similar pattern was observed for rational processing, with higher adherence associated with significantly greater improvement ($U = 102.00$, $p = 0.041$). These findings suggest that greater exposure to the intervention was associated with enhanced cognitive outcomes.

4. Discussion

The present secondary analysis demonstrated that participant adherence was significantly associated with improvements in cognitive processing. Adolescents who attended at least 90% of scheduled sessions exhibited significantly greater gains in both intuitive and rational processing than those with lower attendance, indicating that the magnitude of cognitive improvement was associated with the consistency of participation.

Adherence is widely recognised as an important component of implementation fidelity and determines the extent to which participants receive the intended intervention dose (Carroll et al., 2007). School-based interventions frequently encounter challenges related to absenteeism, examinations, extracurricular commitments and illness, all of which may reduce intervention exposure. Despite these practical constraints, more than two-thirds of participants in the present study maintained attendance above 90%, reflecting strong participant engagement and the feasibility of delivering the programme within the school setting.

The observed association between adherence and improvements in intuitive processing suggests that repeated exposure may be important for cognitive changes to emerge. Repeated practice may be important for developing processes such as attentional regulation, self-monitoring and rapid information processing. Instead, these abilities may develop gradually through repeated practice, allowing participants to internalise cognitive strategies and apply them more efficiently over time.

Similarly, rational processing also demonstrated significantly greater improvement among participants with higher adherence. Although analytical reasoning generally develops over longer periods, regular participation may strengthen executive control, attentional stability and cognitive flexibility, thereby supporting more effective deliberate processing. These findings are consistent with the broader literature indicating that sustained engagement is essential for maximising the benefits of behavioural and educational interventions.

The findings should be interpreted alongside the results of the primary randomized controlled trial. The parent study demonstrated improvements in cognitive processing among participants receiving the intervention compared with controls. The present analysis extends these findings by showing that variability in outcomes within the intervention group was associated with differences in adherence. Thus, intervention fidelity may represent an important contributor to variation in outcomes beyond simple group allocation.

From a practical perspective, these findings highlight the importance of implementing strategies that encourage regular attendance in school-based programmes. Collaboration with schools, scheduling sessions to minimise disruption of academic activities and maintaining participant motivation may support adherence and facilitate consistent participation in school-based programmes.

5. Strengths and Limitations

The study utilised prospectively maintained attendance records and analysed adherence using predefined criteria. Conducting a secondary analysis within a randomized controlled trial framework reduced potential bias associated with intervention delivery and provided an opportunity to examine the association between adherence and cognitive outcomes within the intervention group.

The analysis included only intervention participants, resulting in a relatively small sample size for adherence subgroup comparisons. Attendance was used as the primary indicator of adherence and did not capture participant engagement or practice outside scheduled sessions. Furthermore, categorising adherence using a 90% threshold may simplify what is likely to be a continuous relationship between intervention exposure and cognitive outcomes. Future studies should examine adherence as a continuous variable using correlation or regression analyses.

6. Conclusion

Higher adherence to the intervention was associated with significantly greater improvements in intuitive and rational cognitive processing among adolescents. These findings emphasise that consistent participation may be important for achieving greater cognitive improvement during the intervention period and support the integration of adherence monitoring into future school-based cognitive intervention studies. Promoting sustained engagement may enhance the effectiveness of programmes designed to strengthen cognitive functioning during adolescence.

Declarations

- **Funding:** This study was supported by an institutional seed grant (Grant No. ASG2022013).
- **Conflicts of Interest:** The authors declare no conflicts of interest.
- **Ethical Approval:** Approved by Institutional Review Board-Amrita Institute of Medical Sciences & Research Centre, Kochi, Approval No: **ECASM-AIMS-2024-605**, dated 13-12-2024
- **Informed Consent:** Obtained from all participants (and from parents/guardians where applicable).
- **Author Contributions:**

- A. **Radhika Sourabh:** Conceptualization, Methodology, Investigation, Statistical Analysis, Data Curation, Writing – Original Draft, Writing – Review & Editing
- B. **Anand Kumar:** Conceptualization, Methodology, Supervision, Writing – Review & Editing and Supervision
- C. **Nandana S:** Investigation, Data Curation, Writing – Review & Editing.
- D. **Renjitha:** Formal Analysis, Statistical Analysis, Writing – Review & Editing.
- **Data Availability:** Available upon reasonable request from the corresponding author.

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