

Effectiveness of Brain-Mind Integrated Neurorehabilitation Intervention (BM-INRI) on Executive Function and Relapse Tendency among Patients with Substance Use Disorder

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ABSTRACT

Substance use disorder (SUD) is associated not only with persistent substance-related behaviors but also with neurocognitive impairments, particularly executive dysfunction, which may compromise self-control, adaptive decision-making, and the ability to cope with relapse-related triggers. Conventional rehabilitation programs may benefit from interventions that simultaneously address cognitive function, emotional regulation, and relapse prevention. Brain-Mind Integrated Neurorehabilitation Intervention (BM-INRI) was developed as a multimodal nursing intervention integrating neurorehabilitation, cognitive rehabilitation, executive function training, mindfulness-based relapse prevention, and relapse prevention strategies. This study aimed to examine changes in executive function and relapse tendency among patients with SUD following BM-INRI. The mean FAB score increased from 5.04 (SD = 2.51) before intervention to 16.33 (SD = 1.43) after intervention, representing a mean increase of 11.29 points (95% CI 10.41–12.18; $t = 26.403$; $p < 0.001$; Cohen's $d_z = 5.39$). The mean relapse tendency score decreased from 52.38 (SD = 3.76) to 23.50 (SD = 4.81), representing a mean reduction of 28.88 points ($p < 0.001$; Cohen's $d_z = 4.47$). Difference scores for both outcomes met the normality assumption.

INTRODUCTION

Substance use disorder (SUD) is a chronic health condition associated with substantial biological, psychological, and social consequences. Contemporary understanding of addiction emphasizes that persistent substance use is accompanied by neurobiological changes affecting reward processing, motivation, decision-making, inhibitory control, and self-regulation. Dysfunction within prefrontal systems is particularly relevant because executive processes are essential for controlling impulses, evaluating consequences, and maintaining goal-directed behavior (Koob & Volkow, 2016; Volkow et al., 2016).

Executive dysfunction is increasingly recognized as an important clinical concern in addiction rehabilitation. Patients with SUD may experience difficulties in inhibitory control, cognitive flexibility, working memory, planning, problem solving, and adaptive decision-making. These difficulties can interfere with the ability to apply coping strategies and resist substance-related cues or emotionally challenging situations (Goldstein & Volkow, 2011; Verdejo-García et al., 2019).

Relapse is similarly understood as a multifactorial phenomenon rather than simply a failure of motivation. Cognitive processes involved in reward-based decision-making, impulse control, emotional regulation, and response to substance-related cues may influence relapse-related outcomes. Consequently, rehabilitation programs that address only behavioral abstinence may not adequately target the neurocognitive mechanisms associated with vulnerability to relapse.

Cognitive rehabilitation and executive function training have been increasingly investigated as approaches for addressing neurocognitive deficits associated with substance use. Structured cognitive training may improve attention, working memory, executive processing, and problem-solving abilities, although the characteristics and intensity of interventions vary considerably across studies (Alves et al., 2021). This suggests the need for structured approaches that can be integrated into routine rehabilitation services.

Mindfulness-based interventions provide a complementary therapeutic approach. Mindfulness-based relapse prevention emphasizes awareness of internal experiences, including thoughts, emotions, craving, and bodily sensations, while reducing automatic reactions to these experiences (Bowen et al., 2014). Rather than attempting to eliminate craving completely, mindfulness encourages individuals to recognize craving and emotional responses without automatically translating them into substance-use behavior.

LITERATURE REVIEW

The combination of neurocognitive rehabilitation, executive function training, mindfulness, and relapse prevention may therefore provide a more comprehensive approach to addiction rehabilitation. The rationale is that cognitive training can target executive processes, mindfulness can strengthen awareness and emotional regulation, and relapse prevention strategies can help patients recognize triggers and develop adaptive coping responses.

Based on this rationale, Brain-Mind Integrated Neurorehabilitation Intervention (BM-INRI) was developed as a structured nursing intervention combining neurorehabilitation, cognitive rehabilitation, executive function training, mindfulness-based relapse prevention, and relapse prevention strategies. Unlike interventions that evaluate these approaches separately, BM-INRI seeks to integrate them into a single rehabilitation package that can be implemented within a hospital-based rehabilitation setting. The research gap identified in the study was the limited availability of structured multidomain rehabilitation models integrating executive function, emotional regulation, and relapse prevention within routine addiction rehabilitation services.

Therefore, this study aimed to examine changes in executive function and relapse tendency following BM-INRI among patients with SUD undergoing rehabilitation.

METHODOLOGY

Study Design

This study employed a quantitative pre-experimental design using a one-group pretest-posttest approach. Participants were assessed before the intervention and reassessed after completing the BM-INRI program.

The design can be represented as:

$$O_1 \rightarrow X \rightarrow O_2$$

where O_1 represents the pretest, X represents BM-INRI, and O_2 represents the posttest. Because no control group was included, the study was designed primarily to evaluate within-person changes following the intervention rather than establish definitive causal effectiveness.

Participants and Setting

The study was conducted at Manah Shanti Mahottama Mental Hospital, Bali, Indonesia, among patients participating in a substance use rehabilitation program. The study included 24 participants. Total sampling was used because the number of eligible patients available during the study period was relatively small, resulting in the inclusion of all eligible participants. All participants were male because the rehabilitation unit in which the study was conducted provided care for male rehabilitation patients.

Intervention

BM-INRI was implemented for eight weeks, with two sessions per week, resulting in 16 intervention sessions for each participant. The intervention was delivered according to the BM-INRI manual and standard operating procedures. Implementation fidelity was monitored using an intervention checklist.

The intervention consisted of five integrated components:

1. Neurorehabilitation;
2. Cognitive rehabilitation;
3. Executive function training;
4. Mindfulness-based relapse prevention; and
5. Relapse prevention strategies.

The conceptual basis of BM-INRI is that improvement in executive control, emotional regulation, awareness of craving, and coping with high-risk situations may support more adaptive behavioral regulation during recovery.

Outcome Measures

a. Executive Function

Executive function was assessed using the Frontal Assessment Battery (FAB). The FAB consists of six domains: conceptualization, mental flexibility, motor programming, sensitivity to interference, inhibitory control, and environmental autonomy. Each domain is scored from 0 to 3, resulting in a total score ranging from 0 to 18, with higher scores indicating better executive functioning.

b. Relapse Tendency

Relapse tendency was measured using the Relapse Tendency Scale used in the study. The instrument originated from the scale developed by Rozi (2016) and was subsequently modified in previous research with reference to relapse stages described by Gorski and Miller. Importantly, the scale was used to assess relapse tendency, not to determine whether an individual would actually experience future relapse.

Data Collection

Baseline assessments were performed before implementation of BM-INRI. Participants subsequently completed the eight-week intervention. After completion of all 16 sessions, the same instruments were administered as posttests.

Statistical Analysis

Descriptive statistics were used to summarize participant characteristics and outcome scores. Normality was assessed using the Shapiro-Wilk test. Because the purpose of the paired analysis was to examine within-participant change, normality was evaluated on the difference scores. The FAB difference score was normally distributed ($p = 0.191$), as was the relapse tendency difference score ($p = 0.558$). Therefore, paired t -tests were used to compare pretest and posttest scores. Statistical significance was defined as $p < 0.05$ using two-tailed testing. Cohen's d_z was calculated to describe the magnitude of within-participant change.

Ethical Considerations

The study followed principles of research ethics, including respect for autonomy, beneficence, non-maleficence, and justice. Participation was voluntary, and procedures were designed to minimize potential physical, psychological, and social risks to participants.

RESEARCH RESULTS

Participant Characteristics

Twenty-four patients participated in the study. All participants were male. Most had secondary-level education (16 participants; 66.7%). Eight participants (33.3%) were employed, six (25.0%) were unemployed, and ten (41.7%) were classified in the other employment category. Regarding substance type, methamphetamine/shabu was the most frequently reported substance, used by 10 participants (41.7%), followed by gorilla tobacco (25.0%), alcohol (20.8%), and cannabis (12.5%). The heterogeneity of substances is important when interpreting the findings because the study was not restricted to a single substance-use profile.

Changes in Executive Function

Before BM-INRI, the mean FAB score was 5.04 (SD = 2.51), with a median of 4.00 and a range of 2–10. Following the intervention, the mean score increased to 16.33 (SD = 1.43), with a median of 16.50 and a range of 14–18. The mean increase was therefore 11.29 points. The paired analysis showed a statistically significant increase in executive function. The mean change was 11.29 points, with a 95% confidence interval of 10.41–12.18, $t = 26.403$, $p < 0.001$. Cohen's d_z was 5.39, indicating a very large within-group effect.

Table 1. Changes in Executive Function Before and After BM-INRI

Outcome	Pretest Mean $\pm$ SD	Posttest Mean $\pm$ SD	Mean Change	95% CI	t	p	Cohen's d_z
FAB	5.04 $\pm$ 2.51	16.33 $\pm$ 1.43	+11.29	10.41–12.18	26.403	<0.001	5.39

Changes in Relapse Tendency

The mean relapse tendency score before intervention was 52.38 (SD = 3.76), with a median of 51.50 and a range of 48–60. Following BM-INRI, the mean score decreased to 23.50 (SD = 4.81), with a median of 24.50 and a range of 17–30. The mean reduction was 28.88 points. Because higher scores indicate greater relapse tendency, this reduction represents a favorable change. The paired analysis showed a statistically significant reduction in relapse tendency, with $p < 0.001$ and Cohen's $d_z = 4.47$.

Table 2. Changes in Relapse Tendency Before and After BM-INRI

Outcome	Pretest Mean $\pm$ SD	Posttest Mean $\pm$ SD	Mean Change	p	Cohen's d_z
Relapse tendency	52.38 $\pm$ 3.76	23.50 $\pm$ 4.81	–28.88	<0.001	4.47

Overall, both study outcomes changed significantly following the intervention: executive function increased by 11.29 points, whereas relapse tendency decreased by 28.88 points.

DISCUSSION

This study found substantial changes in both executive function and relapse tendency after implementation of BM-INRI. Executive function improved from a mean FAB score of 5.04 to 16.33, while relapse tendency decreased from 52.38 to 23.50. Both changes were statistically significant, with very large within-group effect sizes. The magnitude of the observed change in executive function is clinically noteworthy. At baseline, participants demonstrated low FAB scores, suggesting considerable impairment in executive functioning within the studied rehabilitation population. Following the intervention, the mean score approached the upper end of the FAB scale.

The improvement is theoretically consistent with the neurocognitive basis of addiction. Chronic substance use has been associated with dysfunction in prefrontal systems involved in inhibitory control, decision-making, cognitive flexibility, and goal-directed behavior. These processes are particularly important in rehabilitation because patients must repeatedly inhibit automatic responses and apply newly learned coping strategies when confronted with substance-related cues or stressful situations.

The cognitive component of BM-INRI may have contributed to this change by providing structured and repetitive opportunities to engage executive processes. Cognitive rehabilitation emphasizes systematic exercises designed to improve or compensate for deficits in attention, memory, executive processing, and problem solving (Cicerone et al., 2019). Similarly, executive function training specifically targets inhibitory control, flexibility, problem solving, and adaptive decision-making.

The findings are also consistent with previous evidence suggesting that cognitive training can improve neurocognitive domains among individuals with SUD. Alves et al. (2021) reported beneficial effects of cognitive training on memory, executive functioning, and processing speed, although substantial heterogeneity exists across intervention protocols. The present study extends this evidence by evaluating a multidomain intervention rather than a cognitive intervention alone.

The second major finding was a substantial reduction in relapse tendency. The mean score decreased by 28.88 points, with a very large within-group effect size. This finding is conceptually relevant because relapse vulnerability is influenced by the individual's ability to regulate responses to craving, emotional distress, environmental cues, and high-risk situations.

One potential mechanism is the mindfulness component of BM-INRI. Mindfulness-based relapse prevention encourages patients to observe thoughts, emotions, bodily sensations, and craving without automatically responding to them through substance use. Bowen et al. (2014) demonstrated the relevance of mindfulness-based relapse prevention in substance use treatment, while subsequent reviews have suggested that mindfulness interventions may contribute to reductions in substance-related outcomes and improvements in emotional regulation.

The relapse prevention component of BM-INRI may provide an additional behavioral bridge between cognitive improvement and real-world recovery.

Patients are encouraged to identify triggers, anticipate high-risk situations, develop coping strategies, and maintain adaptive responses. This is particularly relevant because improved cognitive capacity alone may not necessarily translate into sustained behavioral change without opportunities to apply those abilities in emotionally and socially challenging situations.

An important feature of BM-INRI is therefore its multidomain structure. The neurorehabilitation and cognitive components target neurocognitive functioning; executive function training targets control processes; mindfulness targets awareness and emotional regulation; and relapse prevention strategies target application of these skills to situations associated with relapse vulnerability.

The simultaneous improvement in executive function and reduction in relapse tendency is consistent with the theoretical proposition that stronger executive control may facilitate better self-regulation. Individuals who are better able to inhibit automatic responses, evaluate consequences, and shift strategies may be better positioned to manage craving and high-risk situations. However, this relationship should not be interpreted as a statistically demonstrated causal pathway in the present study. The study did not perform correlation or mediation analyses between changes in executive function and relapse tendency. Therefore, the observed parallel changes should be interpreted as theoretically related rather than evidence that improvement in executive function directly caused the reduction in relapse tendency.

The large effect sizes observed in this study should also be interpreted cautiously. Although Cohen's d values of 5.39 and 4.47 indicate very large within-group changes, effect sizes in uncontrolled pretest–posttest studies may be influenced by factors other than the intervention itself, including natural recovery, concurrent rehabilitation activities, repeated testing, regression to the mean, and changes occurring during the rehabilitation period.

The study population was also relatively homogeneous in sex but heterogeneous in substance type. All participants were male, and methamphetamine was the most frequently used substance. Therefore, the findings cannot automatically be generalized to female patients or populations dominated by other substance-use patterns.

Despite these limitations, the findings have practical implications for nursing and addiction rehabilitation. Assessment of executive function may help clinicians identify neurocognitive rehabilitation needs, while structured interventions addressing cognition, mindfulness, and relapse prevention may complement existing psychosocial rehabilitation programs.

Future studies should use randomized controlled or controlled quasi-experimental designs, larger samples, more diverse populations, and longer follow-up periods. Importantly, future research should also measure actual relapse events, duration of abstinence, adherence to rehabilitation, quality of life, and social functioning rather than relying exclusively on relapse tendency.

Clinical and Nursing Implications

The findings suggest that addiction rehabilitation may benefit from incorporating neurocognitive assessment and rehabilitation alongside conventional psychosocial interventions. For nursing practice, BM-INRI offers a structured framework that potentially allows nurses to participate more actively in interventions targeting executive functioning, emotional regulation, and relapse prevention. The intervention may be particularly relevant in hospital-based rehabilitation settings where nurses have frequent contact with patients and can reinforce therapeutic strategies throughout the rehabilitation process. However, BM-INRI should currently be considered a promising adjunctive intervention rather than an established replacement for standard addiction treatment, because the present study lacked a comparison group.

CONCLUSION AND RECOMMENDATIONS

BM-INRI was associated with significant improvement in executive function and reduction in relapse tendency among patients with SUD undergoing rehabilitation. The mean FAB score increased from 5.04 to 16.33, with a mean improvement of 11.29 points and a very large within-group effect size (Cohen's $dz = 5.39$). Meanwhile, relapse tendency decreased from a mean of 52.38 to 23.50, representing a mean reduction of 28.88 points with a very large effect size (Cohen's $dz = 4.47$). These findings provide preliminary support for BM-INRI as a multimodal rehabilitation approach integrating neurocognitive rehabilitation, executive function training, mindfulness, and relapse prevention. Nevertheless, because the study lacked a control group, the findings should be interpreted as evidence of significant pre-post change rather than definitive proof of causal effectiveness. Randomized controlled trials involving larger and more diverse populations and incorporating long-term follow-up and actual relapse outcomes are warranted.

ADVANCED RESEARCH

Several limitations should be considered. First, the study used a one-group pretest-posttest design without a control group. Consequently, the observed changes cannot be attributed exclusively to BM-INRI. Second, the sample consisted of only 24 participants, limiting statistical generalizability. Third, all participants were male because of the characteristics of the rehabilitation unit in which the study was conducted. Generalization to female patients therefore requires further investigation. Fourth, the participants used different types of substances, creating clinical heterogeneity that could not be explored in detail because of the limited sample size. Fifth, relapse tendency was assessed rather than actual relapse occurrence. Therefore, the findings demonstrate changes in a relapse-related psychological/behavioral tendency and should not be interpreted as evidence that BM-INRI prevents future relapse events. Finally, outcomes were assessed immediately after the intervention, without long-term follow-up. The durability of the observed improvements remains unknown.

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