Effectiveness of Combined Repetitive Transcranial Magnetic Stimulation and Community Reinforcement Approach for Smoking Cessation

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Abstract

Background: Among smokers who are aware of the ill effects of smoking, are interested in quitting. Their quitting efforts consist of simple clinical counseling and medications. Based on a review of the literature, the purpose of this research was to determine the impact of combined transcranial magnetic stimulation (rTMS), which is one method for manipulating brain circuitry, and the community reinforcement approach (CRA), which is based on the concept that contextual factors may either encourage or discourage substance addiction and emphasizes constructive social support alternatives as the most effective technique utilized for smoking cessation.

Method: It was an experimental study, that included 60 male smokers, aged 20 years to 45 years divided into two equal groups. The first group received both the rTMS intervention and the CRA therapy sessions, whereas the second group only received the rTMS intervention.

Main Findings: The findings of the study revealed that group 1, which received both rTMS and CRA indicated that higher levels of smoking behavior at pretreatment subsequently decreased in the post-treatment and follow-up whereas group 2, which received only rTMS indicated that higher levels of smoking behavior at pretreatment subsequently decreased in the post-treatment and subsequently increased in the follow-up.

Conclusions: It was concluded that participants who received both CRA and rTMS were higher on smoking cessation as compared to the participants who received only rTMS sessions.

Keywords: rTMS, Repetitive Transcranial Magnetic Stimulation, CRA, The community Reinforcement Approach

1. Introduction

The most frequent drug use problem in the world is tobacco use disorder. It is characterized by desire and withdrawal, obsessive use despite negative consequences, and relapses, and is linked to a variety of health issues and futile efforts at quitting (Goodchild et al., 2018; Halpern et al., 2018; Benowitz, 2010). By far the majority of smokers regard tobacco use as dangerous and wish to minimize or discontinue consumption. Unfortunately, the recurrence rate for those who try to quit smoking on their own is over 85%, with the majority of them resuming their habit within seven days (Borland, et al., 2012). Long-term outcomes, on the other hand, are minimal, with half-year resistance rates ranging from 19% to 33% (Hays & Ebbert, 2010; Herman & Sofuoglu, 2010)**.** Nicotine's effects on the central nervous system are largely responsible for smoking's habit-forming features (Feil et al., 2010). This psychoactive component of tobacco affects the mesolimbic dopamine pathway, which originates in the ventral tegmental area and leads to reward-related brain regions such as the prefrontal cortex (PFC). Nicotine also alters the limit of gamma-aminobutyric acidergic pathways to suppress the dopaminergic movement, and long-term usage results in long-term neuroadaptations and altered cortical edginess (Vizi & Lendvai, 1999).

Reduced reward-related circuitry activity during withdrawal, corresponds with levels of desire, relapse, and chronic nicotine use (Dinur-Klein et al., 2014). Repeated transcranial magnetic stimulation (rTMS) is one method for manipulating this circuitry, and it can produce dopamine release as well as long-term changes in neuronal excitability (Pell et al., 2011). As it employs time-varying electromagnetic fields to regulate covert brain behavior. A TMS coil is

placed against a person's skull, and brief electromagnetic pulses (»4 ms) within the loop generate small electric fluxes in the cerebrum by electromagnetic enlistment, decreasing cortical volatility at lower excitation frequencies (5 Hz). Various coil configurations are used to generate brief focused electromagnetic pulses that penetrate the brain to activate its regions through targeted axonal depolarization (Thut & Pascual-Leone, 2009). The choice of an rTMS coil is determined by the need for excitement, profundity, and significance (Shevorykin et al., 2022; Lu & Ueno, 2017). A typical TMS mediation starts with aligning the TMS sensation force by assessing the individual's resting motor threshold (rMT), which is assessed by activating the motor cortex while tailoring the TMS dosage to cortical excitability (Young et al., 2021).

Furthermore, when people go through treatment for smoking cessation, they may experience a lack of support while abstaining from substance use, which can make long-term recovery challenging (Higgins et al., 2004). To address the reinforcement deficit that is produced during treatment admission from a more behavioral aspect, researchers developed the community reinforcement technique, which directly addresses the reinforcement process (Petry, 2013; Higgins et al., 2007). The Community Reinforcement Approach (CRA) is one of the cognitive-behavioral strategies based on the concept that contextual factors may either encourage or discourage substance addiction (Hunt & Azrin, 1973). It is a biopsychosocial approach to change a substance-abusing lifestyle. CRA acknowledges the significance of natural phenomena, examines their utilization and emphasizes constructive social support alternatives (Meyers & Smith, 1995). Theoretically, CRA is predicated on the belief that drug-related reinforcers and a scarcity of alternative reinforcers unrelated to substance usage perpetuate dependency. According to this viewpoint, developing alternative rewarding social activities that are incompatible with drug use is critical for initiating and maintaining sobriety. To create a more gratifying lifestyle than smoking or substance addiction, an emphasis is made on modifying environmental variables in parts of life such as labor, recreation, family participation, and so on. CRA incorporates not just cognitive behavioral but also pharmaceutical therapies (Roozen et al., 2004).

The Community Reinforcement Approach (CRA), is based on operant conditioning, has been used to support people in changing their routines so that healthy, drug-free living becomes pleasurable. As a result, practitioners encourage clients to engage in non-substance-related gratifying social activities and to concentrate on increasing their happiness with family and friends (Meyers & Miller, 2001). CRA works to advance encouraging feedback from balance through a variety of procedures aimed at increasing inspiration, improving adaptability, enhancing the role of relatives for recovery and developing encouraging and positive feedback from the environment. Financial incentives are used in the early stages of CRA to address the support shortfall at the treatment section, and motivators are gradually lowered as therapy advances and support ascends in other areas of a person's life. To help clients to modify their addictive behavior, CRA has two key goals: Positive reinforcement for addiction is eliminated and increased for sobriety (De Crescenzo et al., 2018).

It aims to make rehabilitation more compensatory than drug use by eliminating positive feedback for drug use and increasing encouraging input for keeping abstinent. CRA obtained a distinction level in all investigations on the feasibility of chronic drug use therapy and is categorized as a high-adequacy therapy (Fazzino et al., 2019). The current study will look at the impact of the combined transcranial magnetic stimulation and community reinforcement approach on smoking desires and, ultimately, achieving the goal of smoking cessation.

2. Method

This was an experimental study, involving two equal groups of participants. The first group get both the rTMS intervention and the CRA therapy sessions, whereas the second group only received the rTMS intervention. The population of the study included chronic smokers, who meet the criteria of tobacco use disorder from DSM-V and are willing to participate in the study. The Fagerström Tolerance Questionnaire (FTND) and a short version of the Tobacco Craving Questionnaire (TCQ-SF) were used for assessing the intensity of physical addiction to nicotine as well as to measure the intensity of tobacco cravings. Frontal Assessment Battery (Dubois et al., 2000), a brief battery of six neuropsychological tasks to assess brain capacity was used only for screening. 60 male participants (regular smokers) were recruited from the city of Gujranwala, by using a purposive sampling technique. Later these participants were randomly divided into two equal groups. Participants were between the ages of 25 and 40 (Reitsma et al., 2021), frequent smokers who have acquired a nicotine addiction, and willing to quit smoking (Hooper et al., 2019). Participants who use or were dependent on illegal drugs have major medical or psychiatric conditions or clinically significant laboratory findings, were taking any medication with active central nervous system properties, have a cardiac pacemaker, implanted medication pump or intracranial implants were considered excluded.

3. Instruments

3.1 rTMS Procedure

rTMS was administered over the left dorsolateral prefrontal cortex, suggesting that rTMS has the potential to treat tobacco addiction (Wing, 2013). The resting motor threshold (RMT) was determined by the stimulation of the motor strip and by examining the right abductor pollicis brevis muscle and the stimulation site determined by the movement of

the coil 5cm anterior to the motor threshold location along a left superior oblique plane. Each stimulation train consisted of 50 pulses at 10 Hz, using a 100% resting motor threshold (RMT), 20 trains/day was given with an inter-train interval of 15 seconds.

3.2 CRA Procedure

The cognitive behavioral therapy was based on, CRA (Meyers & Smith, 1995) was used to give support during smoking cessation, and was protocol-driven (Roozen et al., 2000). The researcher conducted this therapy, consisting of five sessions. The sessions were focused on motivation, adherence to treatment and rTMS sessions, functional analysis, and behavior skill training. The "Stimulus Control" procedure (Azrin et al., 1994) was employed to eliminate high-risk social situations that were precursors to smoking and to increase the amount of time spent engaging in smoking-incompatible activities.

4. Results

Data were analyzed by using SPSS's latest version 24.0. Repeated measure ANOVA was used to analyze and compare the data of both groups.

Group 1

Impact of CRA and rTMS on Smoking Behavior (N=30)

Variables	Pretreatment		Post-Treatment		Follow-up		F (2,58)	η^2
	M	SD	M	SD	M	SD		
Smoking Behavior	74.33	6.54	54.57	30.09	35.33	18.32	36.19***	.55

*** $p < .001$

The above table shows the impact of CRA and rTMS on smoking cessation. Results indicated significant mean differences across three conditions $F_{(2,58)}$ =36.19, MSE = 315.20, p =.000, η^2 =.55 with moderate effect size. The findings revealed that higher levels of smoking after the pretreatment (M = 74.33, SD = 6.54) subsequently decreased in the post-treatment (M = 54.57, SD = 30.09) and the follow-up (M = 35.33, SD = 18.32). The paired-wise comparisons indicated that there are significant mean differences in all pairs of scores between the pretreatment, post-treatment, and follow-up.
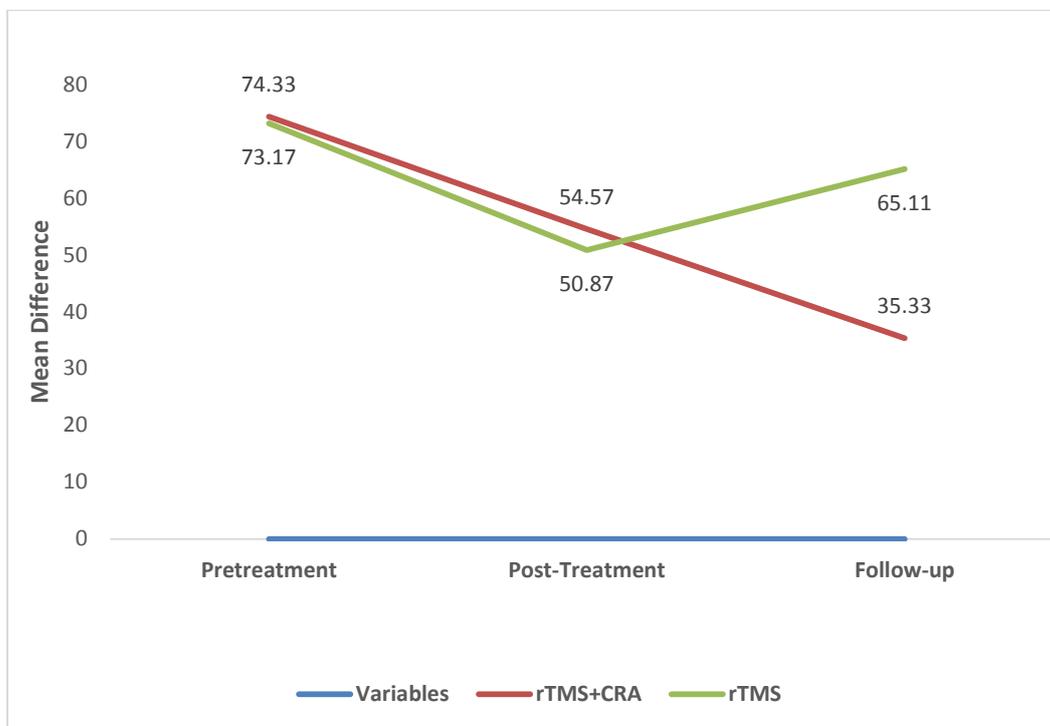
Group 2

Mean, Standard Deviation, Repeated Measures Analysis of Variance for rTMS Sessions on Smoking Behavior (N=30)

Variables	Pretreatment		Post-Treatment		Follow-up		F (2,58)	η^2
	M	SD	M	SD	M	SD		
Smoking Behavior	73.17	8.90	50.87	21.64	65.11	20.08	18.78***	.39

*** $p < .001$

The above table shows the means, standard deviation, and F-value for smoking behavior across consecutive rTMS for smoking cessation. Results indicated significant mean differences across three conditions $F_{(2,58)}$ =18.78, MSE = 234.72, p =.000, η^2 =.39 with a small effect size. The findings revealed that higher levels of smoking after the pretreatment (M = 73.17, SD = 8.90) subsequently decreased in the post-treatment (M = 50.87, SD = 21.64) and then an increase in the follow-up (M = 65.11, SD = 20.08). The paired-wise comparisons indicated that there are significant mean differences in all pairs of scores between the pretreatment and post-treatment, but increased during the follow-up period which indicates higher tobacco cravings among individuals.

The below figure shows differences between group 1 and group 2 based on interventions. It is shown that the combined effect of CRA and rTMS was more effective in tobacco cessations as compared to the independent effect of only rTMS.

Fig. 1 Differences in Group-1 and Group-2 on the Basis of Interventions

5. Discussion

According to the findings of the study, a difference is revealed in smoking behavior among individuals who were treated with the combination of repetitive transcranial magnetic stimulation (rTMS) & community reinforcement approach (CRA) and with the individuals who were treated with rTMS only. Results show differences between group 1 and group 2 based on interventions. The findings of the study revealed that group 1, which received both rTMS and CRA indicated that higher levels of smoking behavior at pretreatment subsequently decreased in the post-treatment and follow-up whereas group 2, which received only rTMS indicated that higher levels of smoking behavior at pretreatment subsequently decreased in the post-treatment and subsequently increased in the follow-up. These findings are consistent with the previous studies as literature revealed that the chance of a successful quit is considerably increased by CRA, especially when accompanied by medication and other modern therapeutic techniques i.e., transcranial magnetic stimulation (Akhtar et al., 2022). Although the Preventive Services Task Force and the 2008 US Public Health Service guidelines both concluded that a more intensive CRA session is more effective than less intensive CRA sessions (Shujaat et al., 2022). The use of behavioral modification strategies that concentrate on associative and self-regulatory mechanisms results in higher smoking cessation rates. Additionally, it appears that behavioral change strategies that encourage commitment, social incentives, and identity linked to changed behavior have better success rates (Shujaat et al., 2022). CRA emphasizes social support during therapy, developing coping mechanisms for withdrawal and quitting, and problem-solving in difficult circumstances (Tobacco, 2008).

The methods through which nicotine in tobacco impacts the brain's reward system and contributes to addiction have been discovered via neurobiological research. The characteristic of addiction, the continuing nicotine or tobacco use despite knowledge of its harmful effects, is facilitated by these alterations in the brain (Akhtar et al., 2022). A key component of the frontal cortex, the insula, is implicated in seeking and relapsing related to smoking. A novel technique known as deep insula/prefrontal cortex TMS (deep TMS), which is successful in aiding smokers in quitting smoking, can be used to modify the activity of the insula. The FDA has officially recognized rTMS as a successful smoking cessation method. It is a physiological intervention that uses magnetic fields to noninvasively activate neuronal activity in certain parts of the brain. Repetitive TMS refers to the administration of many TMS pulses in quick succession (Corrêa, 2022). Two rTMS devices for treating adult depression have received FDA approval. Although still in its early phases, research on rTMS as a smoking cessation therapy has shown promise. High-frequency TMS therapy dramatically decreased the number of cigarettes smoked among adult smokers who had not been able to stop using previous therapies. The efficacy of high-frequency TMS was enhanced and the total abstinence rate increased to 44% at the conclusion of the therapy when combined with exposure to smoking signals. Following therapy, 33% of individuals continued to abstain from smoking (Ho et al., 2022; Sung et al., 2022).

However, even though this intervention was created and is successful at helping individuals stop smoking, only a small number of people have access to it since there are not many locations that are equipped with qualified staff and because the intervention is expensive (Siu et al., 2015). Such interventions would be crucial in the context of a developing nation (Akhtar et al., 2022). However, there is a paucity of information on the expertise, viewpoint, and

smoking cessation practices of local Pakistani doctors. Enhancing the ability and willingness of medical professionals to help smokers would be beneficial (Shaheen et al., 2018; Naeem et al., 2016).

More crucially, smoking cessation may become more likely for smokers as they go along the behavioral model. The fact that some participants in each of the three big smoking cessation trials were able to quit smoking after 3 months and after 1 and 2 years of abstinence definitely supports the idea that smoking cessation may be achieved by smoking reduction. Smoking decreases tend to promote motivation to stop, not undermine it. The rising point prevalence abstinence rates observed in long-term trials are a reflection of the significance of enabling smokers to progressively gain control of their smoking. It should be made very apparent while promoting smoking reduction that completely quitting smoking remains the ultimate aim. But for smokers in the pre-contemplation stage of the health belief model to be responsive to signals about quitting, they must advance along the behavioral model (Sanchez et al., 2021; Black et al., 2020).

According to the data reported in the literature, decreased smoking is a valid therapy option that smokers who are now unable or unwilling to stop can seek. With the combination of different therapies, smoking cessation can be accomplished and sustained over time. In smokers who are unable or unwilling to quit smoking suddenly, smoking decrease also encourages abstinence. When used concurrently with smoking and the use of therapies, nicotine intake does not rise and is well tolerated for reducing cigarette use (Le Houezec & Säwe, 2003).

Tobacco's impact on people and society may be reduced by using effective screening, prevention, and treatment methods. It has been proven that pharmaceutical and psychological therapies are successful in assisting smokers in quitting. It is crucial to expand the accessibility of currently existing therapies and to keep creating new ones because the majority of smokers eventually relapse (Akhtar et al., 2022).

6. Limitations & Suggestions

The results of the current study cannot be generalized since data was collected only from one city and only from male participants who smoked heavily, which cannot be representative of the whole population. There was no comparison group in the study on the basis of demographics. Future research should highlight the differences in smoking cessation, tobacco cravings, and nicotine dependence on the basis of demographics. Individual-level financial, familial, and environmental elements that contribute to reducing or diminishing motivation to quit smoking should be assessed in light of Pakistani culture. Interviews can be used in future research to get detailed information about the research participants. The sample size should be increased. Participants should be recruited from both rural and urban areas.

7. Conclusion

Transcranial magnetic stimulation (rTMS), and combining it with CRA, may be used as the main modern intervention for the smoking habit in Pakistan. Findings revealed that the chance of a successful quit is considerably increased by CRA, especially when accompanied by repeated transcranial magnetic stimulation. The use of CRA with rTMS concentrates on associative and self-regulatory mechanisms resulting in higher smoking cessation rates. Additionally, it appears that behavioral change strategies that encourage commitment, social incentives, and identity linked to changed behavior have better outcomes. The current study has implications in the urban area of Pakistan. For instance, transcranial magnetic stimulation (rTMS), and combing it with CRA, may be used as the main modern intervention for the smoking habit in Pakistan. Overall, this study adds to the evidence supporting the use of rTMS and CRA for smoking cessation by demonstrating that it is a safe and viable therapy for tobacco use problems.

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Declaration of Conflict

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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