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The Effectiveness of Mindfulness, Transcranial Direct Current Stimulation (TDCS), and Brain Gym on Cognitive Empowerment and Psychological Characteristics of the Elderly with History of Falling

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Abstract

Background: Aging is associated with decreased mental and cognitive ability and increased chronic diseases. Identifying therapeutic interventions to improve functional and cognitive responses can greatly help elderly people. Therefore, the present study aimed to determine the effectiveness of mindfulness, transcranial direct current stimulation (TDCS), and Brain Gym on cognitive empowerment and psychological characteristics of the elderly with a history of falling.

Methods: In a semi-experimental trial with a pretest-posttest plan, 32 elderly individuals with a history of falling (mean age 65-75 years) were conveniently and purposefully selected and then randomly assigned to four groups ($n=8$): mindfulness exercise, TDCS, Brain Gym, and control. In this research, mindfulness protocols, TDCS, and Brain Gym were taught in six sessions over three weeks. The data were analyzed by one-way ANOVA and Tukey's post hoc test at the $P\leq0.05$ significance level.

Results: The results showed that TDCS and Brain Gym improved psychological well-being in the elderly with a history of falling compared to the control group in the posttest ($P=0.001$). Mindfulness exercise, TDCS, and Brain Gym improved cognitive empowerment in elderly people with a history of falls compared to the control group in the posttest ($P=0.001$). No significant difference was observed between the effects of mindfulness exercise, TDCS, and Brain Gym on psychological well-being and cognitive empowerment ($P<0.05$).

Conclusion: Based on the findings, there is no difference between the beneficial effects of non-invasive brain stimulation interventions and mental exercise on the cognitive empowerment and psychological characteristics of elderly people with a history of falls.

Keywords: Mindfulness, TDCS, Brain, Cognitive, Characteristics

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Introduction

The world's population is aging at a high rate. We are facing a future in which the number of elderly people will outnumber children and there will be more elderly people than ever before (1). The significant increase in average life expectancy in the 20th century is considered one of society's most outstanding achievements. However, the increase in life expectancy is associated with changes in the leading causes of illness and death, creating an "epidemiological transition" due to the reduction of mental and cognitive abilities and the increase of chronic diseases (2). Identifying therapeutic interventions to improve mental and cognitive responses can greatly help elderly people. Recently, non-invasive stimulation interventions with cognitive-motor tasks have been used to increase clinical effects and physical performance (3).

Mindfulness exercises, transcranial direct current stimulation (TDCS), and Brain Gym have attracted increasing attention as methods to directly modify brain states (4-6); these methods in sports science have many effects on neuromuscular, psychomotor, and cognitive aspects (7). These approaches may depend on neural targets simultaneously activated through cognitive tasks or treatments.

The positive effects of non-invasive brain stimulation interventions can open a new window for elderly people and professionals to promote the aforementioned exercise goals to improve cognitive and motor functions. They can

benefit from these methods if they know the advantages of brain stimulation interventions (8). Direct TDCS is one of the more promising and feasible strategies investigated to improve cognitive empowerment, psychological characteristics, and sports performance in various sports activities (9). TDCS is a neurotherapeutic method in which a direct and weak current is introduced to the cortical areas to facilitate or inhibit spontaneous nerve stimulation (10). The effects of TDCS on performance and sports skills have been reported. One of their most important is the simultaneous firing of non-synaptic mechanisms and synaptic mechanisms (9). TDCS exerts its effects by changing the excitability of the target areas in the brain in a polarity-specific way (11). Many researchers have shown that TDCS affects both motor and cognitive performance and increases the beneficial effects of motor learning, motor performance, resistance to fatigue in the target muscles, and reaction time or muscle strength, and has a positive effect on psychological skills in healthy subjects and patients with neurological disorders (12).

Numerous studies have shown that with the Brain Gym program, cognitive decline caused by old age can be minimized, and this improvement will last for months after the program (13-14). Brain exercises develop the neural pathways of the brain through movement. This method can improve psychological and motor cognitive functions, including cognitive flexibility, self-confidence, self-esteem, coordination, communication, focus, memory, stress, and goal achievement. The claimed effects of Brain Gym are explained using a model of brain function (15).

In addition to non-invasive brain stimulation interventions today, achieving higher sports performance requires preparation movements and mental exercises (16). Research in this field shows that mindfulness intervention effectively improves physical performance and psychological factors. Mindfulness is a type of relaxation with attention control that affects sensory processes by influencing the range of attention, opinions, expectations, mood, and emotional regulation (17). Mindful people understand internal and external events freely and without distortion and can deal with a wide range of thoughts, emotions, and experiences (both pleasant and unpleasant) (18). Mindfulness is accompanied by cognitive regulation, treatment of psychological diseases and improvement of sports performance.

Research in the field of effective interventions on psychological characteristics and physical performance in elderly people is not complete and requires further investigation. The results of studies on the effectiveness of TDCS, mindfulness exercise, and Brain Gym on cognitive empowerment and psychological characteristics are minimal. It is important to identify possible effective interventions to improve these skills in elderly people. Therefore, it is necessary to conduct more research on the effectiveness of these interventions in improving these skills. Effective interventions can help cognitive empowerment, an important factor in elderly people. Therefore, according to the mentioned cases, the current research sought to answer whether TDCS, mindfulness, and Brain Gym affect the cognitive empowerment and psychological characteristics of the elderly with a history of falls.

Methods

The current research is semi-experimental. It is practical in terms of the duration of the cross-sectional research and the use of the obtained results. The statistical population of this research included all elderly people of Qom province. The available targeted sampling method was used to select the statistical sample, and a total of 32 elderly people with a history of falling were selected and divided into four groups ($n=8$) with a pretest-posttest plan: mindfulness exercise, TDCS, brain exercise, and control. The sample size was calculated using G*Power statistical software with a 5% significance level ($\alpha=0.05$), 80% test power ($\beta=0.05$), and medium effect size ($d=0.05$), arriving at a total number of 32 cases (8 subjects in each group).

The conditions for entering the research were age 60 and above, not having Alzheimer's (cognitive decline), the ability to follow the set of instructions and the ability to perform brain exercises, not having severe movement problems, voluntary participation, and completing the questionnaire, and the exclusion criteria of the study included not having enough motivation, getting sick during the training sessions, not performing the movements correctly, and not attending the training sessions regularly. Before participating in the research, all the steps and procedures were explained to them, and after full awareness and completion of the medical questionnaire, written consent was obtained from them. Among the volunteers, 32 elderly people with a history of falling were selected and placed in three experimental groups and one control group. In the experimental groups, first, in the familiarization session, the purpose of the training was stated, and the meeting method and general rules governing the meetings were explained to the members. While explaining the rules, maintaining confidentiality, not threatening and blaming others, giving equal opportunities to each member, and doing the homework was emphasized. The interventions were carried out by experts and assistants who were trained to implement mindfulness intervention, TDCS, and the brain gym. Mindfulness and TDCS took place in a room where light and sound standards were met. After the training and practice in the experimental groups, the relevant measurements were done again in all four groups.

In order to evaluate the cognitive empowerment data, the Spritzer Psychological Empowerment Scale (1995) and the Ryff Psychological Well-Being Scale (RPWS)

were provided to the trainers so they could complete the forms before implementing the interventions for each subject. After the interventions, these questionnaires were completed again. In this research, DiPetrillo and colleagues' (19) mindfulness intervention protocol, Paulos and colleagues' (20) electrical brain stimulation intervention, and Denison and Denison's (1997) Brain Gym intervention were used to investigate the factors.

Mindfulness intervention

The research protocol was presented according to Di Petrillo and colleagues' (19) recommendation. The mindfulness protocol was taught in six sessions, each for 1 to 1.5 hours during three weeks. These sessions were conducted by a psychologist. In the first session, the definitions related to mindfulness training, the examination of key psychological factors in sports for concentration, and the preparations for meditation focusing on breathing were presented. The second session discussed focus meditation, body scan meditation, and sitting meditation, focusing on breathing. The practice of yoga and sitting meditation focusing on breathing was done in the third session. The fourth session started with a discussion about home practice and then ended with yoga practice, walking meditation, and sitting meditation focusing on abdominal breathing.

Sitting meditation focusing on breathing, body, and voice, walking meditation, brief sitting meditation focusing on abdominal breathing were covered in the fifth session. Finally, the last session included meditation focusing on exercise, body scan practice, brief sitting meditation focusing on abdominal breathing, the conclusion of the workshop, discussion about the continuation of the practice, a review of strategies for the continuation of the practice, and discussion and continuation of the practice at home, which included six 30-minute mindfulness exercises every day, six days a week.

At the end of each session, we gave the participants an exercise program, and the subjects were asked to do the exercises at least twice a day. At the beginning of every session, the educational materials from the previous session were reviewed, and participants' questions were answered. This training protocol included practical exercises, role-playing, and lectures (Table 1) (19).

Transcranial direct current stimulation intervention

This intervention was carried out in three weeks, with six sessions in a room with suitable light and sound conditions. Its duration was 20 minutes, and its intensity was 2 milliamps. The intervention was performed using two five-by-five cm electrodes.

These electrodes were placed in the F3 and F4 regions based on the international 10-20 mapping system. The regions correspond to the left and right posterior lateral prefrontal cortex, respectively (20). An electrical brain stimulation device named "Activa Dose II" was used to perform the intervention.

The Brain Gym intervention

The Brain Gym group performed the Brain Gym exercises in 6 sessions, 30 minutes each, for three weeks (Table 2) (15).

Spritzer's Psychological Empowerment Scale (1995) and RPWS were used to examine the cognitive empowerment data.

Reef Psychological Well-Being Scale (RSPWB-18)

The psychological well-being scale was designed in 1989 by Ryff. This scale has 18 items, and its scoring is based on a six-point Likert scale from 1 (completely disagree) to 6 (completely agree); The minimum score that can be obtained in this scale is 18, and the maximum score

Table 1. Mindfulness intervention protocol and its implementation steps

Meeting	Duration	Intervention
The first session	90 minutes	Explaining the concept of the workshop; important definitions related to mindfulness training; investigating key psychological factors in sports for concentration; introduction of the group and discussion (20 minutes), preparations for sitting meditation focusing on breathing (10 minutes); discussion of a home practice for the week, which included sitting meditation; summary of the meeting; discussion.
The second session	90 minutes	Discussion about home practice; discussion about concentration meditation; body scan meditation (20 minutes); sitting meditation focusing on breathing (10 minutes); discussion about home exercises for the week, including a body scan appointment; practicing sitting meditation five times; summary of the second session
The third session	90 minutes	discussion about home practice; mindful yoga practice (40 minutes); sitting meditation focusing on breathing (15 minutes); discussion about practicing at home including one session of body scanning, one session of mindfulness yoga practice, and four sessions of sitting meditation practice; summary of the third session
The fourth session	90 minutes	Discussion about home practice; mindful yoga practice (40 minutes); walking meditation (10 minutes); sitting meditation focusing on abdominal breathing (3 minutes); discussing home practice for each week including one session of body scanning, two sessions of mindful yoga practice and three sessions of walking meditation; summary of the fourth session
The fifth session	90 minutes	Discussion about home practice; sitting meditation focusing on breathing, body, and voice (20 minutes); walking meditation (10 minutes); brief sitting meditation focusing on abdominal breathing (3 minutes); discussion about practicing at home including three sessions of sitting meditation, one session of walking meditation, and two sessions of meditation focusing on sports events; summary of the fifth session
The sixth session	90 minutes	Discussion about home practice; meditation with a focus on exercise (13); body scan practice (30 minutes); brief sitting meditation focusing on abdominal breathing (3 minutes); conclusion of the workshop and discussion about the continuation of the exercise; reviewing the strategy to continue the practice; discussion and continuation of practice at home including six mindfulness exercises for 30 minutes a day for six days a week.

Table 2. Names of movements related to the Brain Gym and how to perform them

Name of movements	Definition
The brain buttons	Touch the clavicle with the fingers of the right hand and place the palm of the left hand on the navel. Breathe through the nose for 30 to 60 seconds. This movement relaxes the chest muscles, creating a positive mood and increasing energy in the body. Breathing through the nose stimulates the cerebral cortex and produces alpha waves.
The cross-crawl	Bring the arms and legs together in a crosswise fashion. One can simultaneously listen to music, count, or look to the left or right with each rep; this movement helps the coordination between the two hemispheres.
The owl	Grab the left shoulder with your right hand, take a deep breath, and while exhaling, turn your head to the opposite side, close your eyes, and say softly: Whooo. Repeat three to four times with each hand.
The elephant	To perform this movement, the knees must be bent, the head should rest on one shoulder, and as a horizontal 8 figure is drawn, the ribs should be used to move the entire upper body, following the drawing finger's path. This movement should be repeated with the other hand. Do this three times with your right hand and three times with your left hand. This movement will fully activate the mind and body and improve eye-hand coordination, attention, and balance.
The lazy 8	The participant should draw a horizontal 8 figure, three times with each hand and three times with both hands simultaneously. One can actually draw lazy 8's on paper or a whiteboard or can just imagine that they are drawing them. At the same time with this movement, the person should take a deep breath and follow the drawing finger's tip with the eyes. At the same time with the movement, say: up-down-left-right. Repeat with the other hand, and then, do it with both hands simultaneously.
The double-doodle	This can be done on paper or in the air. Using both hands, draw similar shapes and say simultaneously: outside-down-inside-up; each eye has six muscles, all of which are stimulated in this movement. This movement increases eye-hand coordination.
The thinking cap	Press the outer cartilage of the ears with the thumb and forefinger unrolling it backwards. Move from the top to the earlobe. Pushing reduces blood pressure and tension headaches. Pulling unlocks the temporal bones. While pulling, you should inhale not exhale. This movement should be done five times in one minute. People with heart problems or low blood pressure should not do this movement. It helps working memory, thinking skills, and listening with two ears.
The positive point	Press two points on the forehead above the eyebrows with the fingers of the right and left hand and slowly pull them to the sides. At the same time, think of a situation that gives you positive energy. This movement is suitable for relaxation and it increases hippocampal memory power.
Arm activation	Hold one arm up vertically next to your ear while holding it with the opposite hand, with the opposite arm bent behind your head. Gently try to move your vertical arm in different directions. Simultaneously with the movement, take a deep breath, exhale for four counts, and switch arms.
The glider (keeping balance)	To perform this movement, the participant should sit comfortably in a chair. Cross the ankles. Keep the knees relaxed. Lean forward and try to reach the tips of the toes. As the participant inhales and exhales, they let their arms move down towards the toes, repeating this to the left, right, and center. Switch the legs and repeat. The purpose is to stimulate the respiratory system, stretch the spine, and play the spinal cord.
The earth button	The participant should place two fingers of one hand under the lower lip and the palm of the other hand below the navel. Breathe so that the energy flows to the center of the body. Simultaneously with this movement, take four to six deep breaths and imagine an energy cascade. If it is done for more than two minutes, the person will feel the heat. In the next step, change the hands and repeat the same steps.
The connection movement	The first step is done while standing and sitting (stimulation of the pineal gland or third eye), with eyes closed and abdominal breathing, children for 30 seconds and adults for 60 seconds; the second stage is rubbing the hands together to increase the electromagnetic waves, placing the fingers on the navel with the eyes closed, accompanied by belly breathing while sticking the tongue to the roof of the mouth. This move aims to help relaxation.

is 108, and it has 6 dimensions with 3 questions for each dimension and a total score. In this scale, questions 3, 4, 5, 9, 10, 13, 16, 17 are scored in reverse, and the rest are scored directly. The reliability coefficient of the whole questionnaire was obtained through Cronbach's alpha and the bisection method with the coefficients 0.92 and 0.88, respectively. Also, the correlation between the 18-question psychological well-being scale and the original scale fluctuated from 0.7 to 0.89, which indicates good criterion validity.

Spritzer and Mishra Psychological Empowerment Questionnaire

This questionnaire has 15 questions, and its purpose is to measure psychological empowerment and its dimensions (competence, autonomy, influence, meaningfulness, and trust). It is measured on the Likert scale and has five dimensions, with questions related to competence (1–3), autonomy (4–6), influence (7–9), meaningfulness (10–12), and trust (13-15).

Higher scores indicate greater ability to empower and vice versa. Cronbach's alpha was obtained for the psychological empowerment questionnaire for competence (0.59), autonomy (0.81), influence (0.84), meaningfulness (0.89), and trust (0.88).

The Shapiro-Wilk test was used to determine the normality of the data distribution, and the regression slope was used to assess homogeneity. Also, to investigate the significant changes in each of the research variables between different groups, the one-way analysis of variance method was used, and if a statistically significant difference was observed, Tukey's post hoc test was used to determine the location of the difference between the groups. Calculations were done using SPSS version 26 statistical software at a significance level of $P \leq 0.05$.

Results

Table 3 shows the results of the descriptive statistics related to psychological well-being and cognitive empowerment in the different study groups.

The results showed that TDCS and Brain Gym improved psychological well-being in the elderly with a history of falls ($P = 0.001$).

There is no significant difference between the effect

Table 3. Results of descriptive statistics related to average psychological well-being and cognitive empowerment

Statistics group	Mean ± standard deviation	Electrical stimulation	Mindfulness	Brain Gym	Control
Psychological well-being	Pre-test	75.06 ± 86.5	90.12 ± 4.15	83.62 ± 11.77	85.4 ± 00.62
	After the test	89.75 ± 6.31	85/7 ± 00/11	87/9 ± 37/05	86/7 ± 25/00
Cognitive empowerment	Pre-test	67.5 ± 10.41	67.25 ± 10.31	69/7 ± 37.02	63.12 ± 9.96
	After the test	70.12 ± 13.19	67.50 ± 11.71	73.25 ± 1.28	62.87 ± 10.37

of mindfulness exercises, TDCS, and Brain Gym on psychological well-being ($P = 0.265$).

Mindfulness exercises, TDCS, and Brain Gym improved cognitive empowerment in the elderly with a history of falls ($P = 0.001$). There is no significant difference between the effect of mindfulness exercises, TDCS, and Brain Gym on cognitive empowerment ($P = 0.142$).

Discussion

The results of the present study showed that TDCS and Brain Gym improved psychological well-being in the elderly with a history of falls in the posttest. Also, no significant difference was observed between the effects of mindfulness exercises, TDCS, and Brain Gym on psychological well-being. Recent research has shown that non-invasive brain stimulation methods play an effective role in increasing psychological comfort and reducing mental disorders (21). The results of our study also indicate the positive effects of non-invasive brain stimulation interventions on improving psychological well-being in elderly people with a history of falls.

Our study results contradict previous findings that mindfulness improves psychological well-being in the elderly (7,22). The lack of improvement in psychological well-being in elderly people with a history of falling can be caused by the intervention duration, and effective results may be achieved by implementing more sessions in this protocol. The effectiveness of TDCS on psychological well-being in the elderly with a history of falls in the current study is in line with the results of Pellicciari and Miniussi (23). In explaining this finding, it can be said that the significant effects of direct electrical stimulation of the brain on psychological well-being are achieved by changing the prefrontal cortex and creating a balance between the activity of the prefrontal cortex of the left and right hemispheres. In this regard, Pellicciari and Miniussi stated in their study that stimulation of the dorsolateral prefrontal cortex using direct electric current is associated with changing negative mood to positive emotional state (23).

On the other hand, TDCS increases the ability of the brain to process information and reduce ineffective thoughts because it involves the prefrontal cortex in the processing of mood and excitement. Several mechanisms have suggested the effect of cerebral exercise on psychological performance: increased cerebral blood flow, changes in neural transmission, structural changes in the central nervous system, and altered excitatory levels based on the physical changes that occur as a result of physical activity. It improves executive function, attention, cognitive flexibility, and implicit memory (24). In general, and according to the results and mechanisms of the brain interventions of mindfulness, TDCS, and Brain Gym, it can be concluded that these interventions can help improve the psychological functions of elderly people with a history of falling, and there is no difference between the effectiveness of these brain interventions in improving the psychological functions of elderly people with a history of falling; however, the amount of interventions and the duration of the sessions can affect the results and provide a clearer understanding of the effects of the interventions.

Also, the results of our study showed that mindfulness exercises, TDCS, and Brain Gym improved cognitive empowerment in the elderly with a history of falls. However, no significant difference was observed between the effects of mindfulness exercises, TDCS, and Brain Gym on cognitive empowerment.

Mindfulness training leads to improvements in selective attention and executive functions. Study results show that mindfulness training improves cognitive performance in various fields, including attention, concentration, and other executive functions (25). It has been found that TDCS can be an effective tool for improving cognitive function in the fields of language learning, working memory, attention, and mental calculations (26). However, these results were inconsistent with the research findings of Klaus and Hartwigsen (27) and Ishikuro et al (28). The differences may be due to changes in the specific parameters of the study, including the duration of stimulation, electrode placement, type of patient and pathology, number of sessions, current intensity, timing of stimulation, and lack of confirmation of the long-term effect. In explaining the effect of TDCS on the cognitive performance of the brain, it should be said that considering the importance and role of the brain region on cognitive actions, the stimulation of this region seems to have a great capacity to increase cognitive functions; that is, brain stimulation may increase cognitive functions and cortex excitability in networks related to cognitive functions because this area is involved with cognitive functions and reactions that improve performance in indicators such as goal-based behavior planning memory, response inhibition and inhibitory control in the elderly

(29). The results of the present research are in line with the findings of Cancela et al and Azizah et al, who showed that Brain Gym improves cognitive empowerment in the elderly (30,31). In explaining these findings, it can be said that Brain Gym stimulates different brain areas with special emphasis on the corpus callosum and facilitates interhemispheric communication. Brain Gym has been suggested as a potentially useful physical therapy approach to increase brain function in the elderly (6). However, contrary to the results of our study, Varela et al. stated that Brain Gym did not lead to improved cognitive performance in older adults with and without cognitive impairment (32). The duration of the interventions can be the reason for the difference in the results of the studies.

Brain Gym is considered to be a kind of physical exercise in the first place. Secondly, these regular physical activities cause certain events in the brain and a minimal reduction of cognitive decline caused by old age. Deep and abdominal breathing is done during most Brain Gym exercises, which increases the person's energy level. The oxygenation in the brain is better, the psychological and physical functions of the person are probably improved, and cognitive flexibility increases. Energy exercises improve the necessary connection between the body and the brain for any type of human activity (15). Overall, this study provides useful information about the effectiveness of mindfulness training, TDCS, and Brain Gym as therapeutic approaches to improve cognitive empowerment.

One of the limitations of the current research was that the samples were exclusive to elderly men, so generalizing the findings to other people should be done with caution. Considering the existing theoretical scope, the present findings, and limitations, it is suggested that this research be conducted on other strata and, if possible, in a larger sample size and for a longer period. It is also suggested that in future research, the effectiveness of combined interventions on several motor and cognitive domains in healthy and impaired elderly people be investigated.

Conclusion

In summary, the present research results showed that mindfulness exercises, TDCS, and Brain Gym are effective in improving psychological well-being and cognitive empowerment in the elderly with a history of falling. Also, no significant difference was observed between the effects of mindfulness exercises, TDCS, and Brain Gym on psychological well-being and cognitive empowerment. Therefore, elderly people with a history of falling can use the benefits of all three interventions to improve psychological well-being and cognitive empowerment.

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Authors' Contribution

Conceptualization: Somaye Talighi, Negar Arazeshi, Keyvan Molanourozi, Marzieh Balali.
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Competing Interests

The authors declare that they do not have any conflict of interest.

Ethical Approval

The present study is taken from a professional doctorate dissertation approved by the Islamic Azad University, Central Tehran branch Ethics Committee with the ethical number IR.IAU.QOM.REC.1402.169. All participants read and signed the informed consent form.

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