Original Article

Effect of Cognitive-Behavioral Therapy (CBT) and Transcranial Direct Current Stimulation (tDCS) on Body Mass Index and Self-Control in Overweight Women

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Abstract

Introduction: Considering the growing trend of overweight and its risk, it is necessary to find useful solutions for weight loss. Usually overweight people are involved in several treatment programs that have decent short-term effects, but the symptoms might be relapsed in long term. The purpose of this study was to compare the effectiveness of Cognitive-Behavioral Therapy (CBT) and transcranial Direct Current Stimulation (tDCS) on reducing body mass index and increase self-control in overweight women.

Methods: This is a quasi-experimental study with pretest- posttest design and follow-up. The statistical population of this study included all overweight women referring to the Nutrition Clinic of Shahid Beheshti University of Medical Sciences. The sample consisted of 30 females selected by purposeful sampling method and were randomly assigned to two experimental groups. In this study, BMI was used to assess overweight and Tangney self-control scale was used for self-control.

Results: The findings indicated that the self-control in the participants in the cognitive-behavioral group were more improved in comparison to transcranial Direct Current Stimulation group (p,0.05), while tDCS was more effective than CBT on improving body mass index.

Conclusion: In general, cognitive-behavioral therapy and transcranial Direct Current Stimulation with effect on the area of the brain that is associate with control perception lead to increased self-control, decreased craving and BMI.

Declaration of Interest: None

Keywords:Cognitive behavior therapy (CBT), Transcranial direct current stimulation (tDCS), Body Mass Index (BMI), Self-control, Overweight.

Introduction

Obesity is one of the chronic disorders spreading all over the world which accompanies diseases such as diabetes mellitus type 2, cardiovascular diseases, high blood pressure, various types of cancers, mental and social disorders (1). Obesity is defined as a condition in which excess body fat has accumulated in the adipose tissue abnormally (1). There are several ways to assess and measure obesity and one of the most important assessment is body mass index (BMI). This index is based on weight to height ratio and is defined as the body mass divided by the square of the body height kg/m2. Body mass index has fallen into the following categories based on World Health Organization (WHO,1): BMI from 18.5 up to 25 indicates normal weight. BMI from 25 to 30 has been considered as overweight and over 30 defined as obese. Recent research shows that, the prevalence of obesity and overweight is being increased throughout the world. Approximately 3 percent of Korea and Japan population, 8 percent in Switzerland, 22 percent in Britain and over 30 percent in the United States of America are overweight (2). Based on Iranian research the prevalence of obesity has been reported 18/6 percent among men and 38/3 among women (3). Health study of the country in 2005 indicates that overweight and obesity has been estimated 8/42 percent among men and 57 percent among women in Iran (4).

With regard to a growing trend in overweight and its risk, it is essential to find some useful solutions. Typically, overweight people are obsessed with several treatment plan which have beneficial short-term effects. However, the symptoms would be relapsed in long-term. Factors involved in failing to maintain ideal weight are as follows: Lacking emotional regulation, maladaptive coping strategies and physical inactivity (5). Therefore, one of the most important matters to design an effective treatment to lose weight is identifying effective psychological factors and self-regulation aspects of involved behavior to control weight like: motivation, attitude, purpose and skills. One of the most important approaches is when people are tempted to eat, they lose self-control (6-7). Research conducted on how to control eating have emphasized on physiological mechanisms (8-9). Human beings are provided with weight regulation system which works more towards putting on weight due to reducing risk hunger (2). Most of the people consider their and others eating style unproductive and they feel that, if they had more self-control, they could eat less and they could be healthier (10). Self-control is identified as one's conscious effort towards weight regulation. People who benefit from more self-control, generally consume less calories, choose their food more consciously and lose weight over time. On the other hand, people having less self-control, are prone to overeating or overweight (11-12).

Difficulty in self-control has two aspects: Lack of foresight and postponing the current needs. When there exists no foresight, individuals will focus on consuming food at the moment and they will not have any thoughts or plans for future. Therefore, their health will be weakened over time (13-14). Self-control with regard to obesity has been put forward by Cutleret al. (15). Their findings indicate that such individuals do not suffer

from their body fat. Because only a certain amount of exercise is needed in order to lose individuals' overweight (15). However, their inactivity can be related to such individuals' self-control problem not physical exercises (15).

There are different ways to lose weight; but based on what was mentioned above, Therapeutic methods which boost psychological resources towards being healthy and increasing self-control lead to an improvement on healthy weight loss (16).

The main issue of the growing research background about obesity is to recognize contradictory components in individuals' behaviors and lack of self-control and the purpose is to design interventions to work on the components (16-17). A number of experimental studies have shown that people would rather try short-term methods to lose weight because they lack self-control (18-21). Generally, people prefer short-term impulses and meeting their needs instantly to long-term goals in managing their weight (22) and this affects how people assess benefits and the cost of the behaviors related to weight like: eating food, physical activities and choosing weight loss strategies. For example, when peoples' behaviors who lack self-control result in rewards and meeting their needs instantly, it affects one's decision making and the overweight individual would rather consume unhealthy, affordable and accessible food to healthy one (15) or when they face high costs or delayed rewards, they tend to spend time rather than making use of healthy weight loss strategies (23). Thus, the major problem in weight loss is the psychological conflict between tendency or desire and will (self-control to overcome tendency) and not only does people's success to eat healthy food and be physically active depend on one's tendency but also it is also contingent upon one's control over eating and athletic behaviors (24).

One of the effective treatments for weight loss and boosting self-control is cognitive-behavioral therapy which deals with raising consciousness about eating and behavioral patterns, normalizing eating patterns, reducing to encounter stimulus of unhealthy eating patterns and becoming aware of response in different situations. The aim of cognitive-behavioral techniques is to minimize negative self-talk, irrational goals and increase self-control (25). According to some study, cognitive-behavioral therapy can be an efficient intervention for the correction of irrational beliefs. The purpose of cognitive-behavioral therapy is cognitive restructuring and help people change thinking patterns that are wrong regarding to thought processes and irrational beliefs (26).

A number of researches has studied the effectivity cognitive-behavioral therapy on obesity improvement and weight loss (27) and also low self-esteem and high BMI of obese women (28). For example, Riegeret al. have carried out a research in the field of cognitive-behavior therapy effectivity on obese adults. The research results indicated that such treatment has been effective on weight loss and the follow up after a year showed that, the participant maintained their self-control skills and controlled their weight (29). Furthermore, Murphy et al. came up with the similar conclusion (30). However, Booth et al. (31) performed meta-analysis in the field of cognitive-behavioral therapy effectivity on decreasing overeating. The results of 15 pieces of research with 4539 participants have indicated that, applying cognitive-

behavioral therapy leads to almost 1.36 kg weight loss in a year and 1.23 kg weight loss within two years. Based on researchers' conclusion this change has not been clinically significant so much (31). Oraki and Ghorbani evaluated the effectiveness of mindfulness-based eating awareness training on perceived stress and body mass index. The results showed that mindfulness training significantly decreased perceived stress and also significantly decreased body mass index in overweight women (32).

Other research has paid attention to neurophysiology overeating and have tendency to control eating behaviors in obese people with this attitude. Some research shows that, dopamine pathways in obese and overweight people's brain has become dysregulated (33-34). Other research expresses th imbalance in limbic circuits of the brain and prefrontal lobe which control cognitive and confirmatory aspects of the eating behavior is the cause of obesity (35-37).Brain stimulation may also be a promising tool for reducing food cravings (38). The most common target of neuromodulation is the dorsolateral prefrontal cortex (dlPFC) which has been associated with control of eating via possible mechanisms of reward valuation, attention and inhibitory control (39). Non-invasive brain stimulation with neural discharge in different parts of cortex can affect several disorders. Two of the most common ways are transcranial Direct Current Stimulation (tDCS) and Transcranial Magnetic Stimulation (TMS). Recently Loweet al. have demonstrated in a meta-analysis study that, Cortical neuronal stimulation of prefrontal can decrease temptation to eat while facing signs related to eating (40). For example tDCS applied to the dlPFC reduced food cravings in healthy participants (41) and the desire to eat in overweight and obese participants (42).Moreover, Kekic studied the effect of tDCS on reducing sugar cravings and consuming food and the results illustrate that, tDCS has an impact on reducing temptation to choose high calorie foods and eating calories (43).

The recent studies have demonstrated effectivity of limbic circuit regulation and increase of frontal cortex activity on reducing craving and self-control enhancement (44-45).In the mentioned research tDCS has been used to stimulate cerebral cortex and neurophysiological changes which led to cognitive changes. Neuroimaging studies have shown long-term affectivity of tDCS on weight loss and it has been suggested that, the activity of lateral frontal cortex in a normal situation and in response to food related stimuli can lead to overcoming eating behaviors and enhancing self-control (46-49).

Based on what has been mentioned above, weight loss has been taken into consideration from different therapeutic point of views and its success in therapy is measured with different criteria. According to the researcher’s information, no research has been carried out to compare the effectivity of different attitudes on weight loss, enhancing self-control and mostly important, duration of each therapy effectivity. Ergo, the current study goal is to compares the effectivity of cognitive behavioral therapy (CBT), and transcranial Direct Current Stimulation (tDCS) on weight loss and enhancing overweight women’s self-control.

Methods

This research is a quasi-experimental one with pretest-posttest design and follow-upwith two experimental groups. In this study, therapy has been put forward as the independent variable and was presented as cognitive behavioral therapy (CBT), and transcranial Direct Current Stimulation (tDCS). BMI and self-control were considered as dependent variable. The statistical population of the current research included all overweight women referring to the nutrition clinic of Shahid Beheshti University of medical science using available sampling method. 30 women were selected and randomly assigned to two experimental groups. Participants inclusion criteria were being female, BMI between 25 to 29.9, not having a surgery for weight loss in their record, not having a especial diet, not attending any training classes in order to lose weight, not suffering from psychological disorders, not having physical illness, not abusing drugs and exclusion criteria were not attending more than two therapeutic sessions, not having psychological or acute physical disease during the research. Amplitude and standard deviation of the participants' age in two categories of tDCS and CBT were respectively 31.30±7.09 and 31.70±5.79.

Measures

Body mass index (BMI): In the current study BMI was used to check out overweight. In his index weight in kilograms divided by height in meters squared. Seca digital scale made by Germany with 100 grams error percentage was used to measure weight and a standard tape measure in centimeters (with 0.1 cm accuracy) attached to wall was used to measure height. When measuring, all participant were without any shoes or coverage.

Tangney Self-Control Scale:This scale has been developed by Tangney et al. (50). It has 36 questions and has been set in a five-point Likert-type scale. 1 (never) to 5 (a lot). Scoring range for all the individuals is 36-180. The higher score is indicative of more self-control. Cronbach's alpha in this scale has been reported 0.59 in this scale (50). In Iran test-retest reliability coefficient and Cronbach's alpha in this scale has been respectively reported 0.88 and 0.80 (51).

Intervention methods:

Transcranial Direct Current Stimulation (tDCS): In this method, low direct current is delivered to the brain cortex. When positive stimulation is delivered, the current causes a depolarization and when negative stimulation is delivered, the current causes a hyper-polarization.

This action causes calcium to enter the cell and increases cell activity. Thus, this action increases glucose and oxygen in that area and it helps the brain restoration. In this method, by making a new connection among cells and among healthy cells and damaged ones, rehabilitation, restoration will take place and the performance will be improved in that area. In this study, in order to electrically stimulate the brain cortex, anode electrode (25 cm) was placed on the left side of the forehead area (F3) and cathode electrode (25 cm) was place on the right side of the forehead (F4). Electrical current was adjusted on 2 miliamper (MA) for the duration of 20 minutes. And the gradual time to increase and decrease the current was considered 20 seconds.

Cognitive behavioral therapy (CBT): In this research, Cooper cognitive behavioral therapy for weight loss package (52) was used. This treatment was done in two phases, in 15 group sessions and twice a week. Steps of the first phase of this therapeutic method is as follows: First step: starting treatment (treatment commencement, interacting with person, checking out motivational issues and training them about the received calories durability). Second step: weight fixation (checking out person's eating style, teaching them problem solving skills, cutting calories). Third step: working on weight loss obstacles (weighing, checking out cognitive and behavioral weight loss obstacles and reforming them). Forth step: increasing activity (gradual increase of the person's physical activity and weighting). Fifth step: working on body image concerns (training about role of body image in weight control, recognizing body image concerns, teaching them how to logically face body shape avoidance and paying attention to the goals). Sixth step: working on weight goals (checking out desirable, ideal and tolerable weight and focusing on desirable weight, checking out the obstacles of weight loss). Seventh step: working on initial goals using problem solving attitude. Eighth step: eating healthy (focusing on eating behavior, measuring daily eaten food, planning for diet goals) and in the second phase of weight fixation (learning necessary skills to fix weight and preparation for weight fixation) was used. Necessary duration of each session was estimated 1 hour.

Procedure:

In order to conduct this research, overweight women who were fully satisfied, with BMI between 25 to 29.9 and having inclusion criteria entered the research steps. After communicating with participants and getting their consent, goals of the research, how to conduct it and the reason to choose these people were explained to them. Additionally, information confidentiality was stressed on and participants were reminded that they are able to leave the groups when researching if they would like. Then they started to complete Tangney Self-Control Scale. The participants were wanted to ask for explanation if they faced any ambiguity while completing the questionnaire to make it clear. After implementing pretest, participants were randomly assigned in two experimental groups. It is worth mentioning that, all the participants were got written consent to attend training sessions. After completing pretest, cognitive behavioral therapy based on cognitive behavioral therapy weight loss package by Cooper (52) in 15 sessions of 20 minutes for the duration of two months and in a group was implemented on the experimental group. The second group was provided with daily electrical brain stimulation for 15 sessions of 20 minutes. All the participants were evaluated by research tools at the first, last sessions and 45 day after finishing treatment. Follow up test was done in order to evaluate sustainability and durability effect of therapeutic interventions.

Results:

Data analysis was done using descriptive statistics methods (mean and standard deviation) and inferential statistics (analyses of covariance with observance of

its assumption) and using 22- SPSS statistical software.

Table1: pretest, post-test and follow up mean and standard deviation for experimental and control groups

Variable	Group	pretest	Post-test	Follow up
		mean (Std. deviation)	mean (Std. deviation)	mean (Std. deviation)
Self-control	CBT	70.88(6.98)	90.23(6.22)	86.52(7.14)
	tDCS	7.34(5.68)	87.94(7.59)	85.76(7.28)
BMI	CBT	27.08(1.62)	26.82(1.58)	26.22(1.65)
	tDCS	26.96(1.37)	25.63(1.16)	26.71(1.23)

Table 1 demonstrates that, self-control and BMI mean of the cognitive behavioral therapy group in pretest was respectively 70.88 and 27.08, 90.23 and 26.82 in post-test and 86.52 and 26.22 in follow up; and in electrical brain stimulation group in pretest respectively 70.34 and 26.96, in post-test 87.94 and 25.63 and in follow up 85.76 and 26.71.

The results of Levene's tests range of experimental and control groups in dependent variables is indicative of variances equality in both groups (F=1.15; P>0.01) and Kolmogorov–Smirnov (F=0.39; P>0.01) is indicative of homoscedascity and normal distribution of variables. Other assumptions like linear relationship of correlation between covariant and dependent variables (multiple nonlinearity), no correlation between covariant variable (and regression line slope), interaction between groups and pretest confirms that using these statistical methods to analyze dependent variables is allowed.

Table 2: The results of covariance analysis of variance tests for dependent variables post test

variables	Sum of squares	df hypothesis	F	P	Eta-squared (η2)
Self-control	4817.66	1	16.02	0.01	0.36
BMI	39.26	1	6.77	0.05	0.18

Based on what has been mentioned in table 2, there is a significant difference between experimental groups in self-control variable (F=16.02, P<0.01) and BMI (F=6.77, P<0.05) after controlling pre-test which indicates that self-control variable in participants of Cognitive behavioral therapy group has been improved comparative to electrical brain stimulation group. On the other hand electrical brain stimulation has but more effective in BMI improvement than cognitive behavioral therapy.

Table 3: The results of covariance analysis of variance tests for dependent variables in follow up

variables	Sum of squares	df hypothesis	F	P	Eta-squared (η2)
Self-control	5152.67	1	1.872	0.36	0.05
BMI	22.88	1	1.35	0.15	0.09

As it can be seen in Table 3, there is no significant difference between two experimental groups in self-control variable (F=1.87, ns) and BMI (F=1.35, ns) which indicates similar durability of two intervention methods effectivity in follow up step.

Discussions and conclusion:

The goal of the present study was to compare the effectiveness of cognitive behavioral therapy (CBT) and transcranial Direct Current Stimulation (tDCS) on body mass index and self-control in overweight women. Data analysis indicated that self-control variable in cognitive behavioral therapy participants have improved comparing to electrical brain stimulation. While, electrical brain stimulation has been much more effective in BMI improvement than cognitive behavioral therapy.

Many studies have proven the affectivity of CBT on eating disorder and weight loss in their studies which are favorable with the current research results (25, 29-30). The fundamental principal of cognitive behavioral therapy is based on the fact that a person's behavior and emotion contingent upon how they interpret the world to a large extend. This therapy helps people overcome their problems by changing their thought, behavior and inefficient emotional response. One of the explanations of the current research that can be defined is that cognitive behavioral therapy aims individual's conscious choice to choose healthy food and by teaching eating method, conscious attention reduces reward signals by the usage of reward transformation and finally leads to improving behavioral and cognitive self-control in overweight people (53).

Various studies have shown that reacting to symptom and rewarding sensibility may be effective in self-control improvement with exposure methods with symptoms accompanying response inhibition in which relationship between food symptoms and overeating is disappeared (54-55). In this method, conditional relationship between food and its symptoms such as smell will be broken by continuous companionship of food symptom without accessing food. The effectivity of his method in reducing craving and enhancing self-control in eating disorders has been proven (54-55). Since habits unlike goals start automatically and without effort; eating behavior also starts without necessity of cognitive control and conscious attention in spite of environmental symptoms. Thus, in the explanation of the current research, it can be pointed out that automatic response process to environmental symptoms in cognitive behavioral therapy is aimed in order to create more conscious choice process and enhance self-control (56). Furthermore, some studies have illustrated that, teaching how to control selective attention in removing impulsive responses before facing stimulus is effective (57). Therefore, the current research results can explain that cognitive behavioral therapy can be effective by reducing attention bias and impulsive choices related to food and reward.

One of the other results of the current study indicated that electrical brain stimulation is effective on reducing body mass index which is favorable with numerous studies (46-48). Eating behavior is a complicated behavior which is related to biological, psychological and environmental factors and deciding

whether to eat or not to eat is adjusted by the brain (58). For instance, dopamine neurotransmitter plays a prominent role in various psychological disorders including eating disorders (59), overweight and obesity. MRI studies have shown that being faced with high calorie food leads to more activity of neural dopaminergic pathways in obese and overweight people than normal individuals (60). Dopamine has a moderating role in cortical mesolimbic system. This pathway plays role in reward and instant reinforcement (61) and also increasing activity in this area in people who cannot control impulse has been reported (62). On the other hand, mesocortical pathway plays role in movement control, relationship between stimulus-response and reward, reward prediction error and cognitive flexibility (63). Also, studies have shown prefrontal cortex plays role in increasing impulsivity and reducing inhibition (64). Reducing dopaminergic activity in mesocortical system can lead to neuromarker for impulsivity, being involved with obsessive behaviors and finally overeating in overweight people. In these people failing to inhibit mesolimbic dopamine system leads to increasing reward value and inhibition system will be disrupted (65-66); thus, mesolimbic and mesocortical pathways are predictive of rewarding behaviors or eating inhibition and it has a significant impact on overweight and obesity and since electrical brain stimulation in prefrontal cortex causes to activity reduction in neural pathways, It can decrease craving and leads to decrease body mass index.

Another explanation of the result of the study is the fact that the activity of prefrontal cortex posterior lateral, a part of the brain which is related to impulse and cognitive inhibition (67) which has a positive correlation with healthy food selection and negative correlation with body weight (68) and also this area is in charge of actions recognition and determination, evaluating the next consequences of the current behavior and predicting consequences and social control. (69). So a probable explanation of the current research is that stimulating this area leads to social control enhancement and decreasing craving which subsequently results in decreasing body mass index and more fundamental effects in the brain.

Generally, the results of the current study demonstrated that, numerous cognitive and behavioral strategies like eliminating created connection among selective attention, impulsive response and cognitive control are effective on overweight people. On the other hand, electrical brain stimulation has an impact on brain function and structure. Particularly on prefrontal areas. Since this part of the brain is related to control perception, effectivity on this part can result in reducing craving and body mass index. To point out some of the possible limitations of this study was failing to check out functional and structural changes of the brain. Thus, it is recommended that future research examine the treatment effectivity and its impact on the brain function by using accurate and advanced instruments like fMRI and PET scan.

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