비만치료에 있어서 환자특성에 따른 인지행동요법과 행동수정요법의 효과 비교: 체계적 문헌고찰 및 메타분석

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Comparison of the Effects of Cognitive Behavioral Therapy and Behavioral Treatment on Obesity Treatment by Patient Subtypes: A Systematic Review and Meta-analysis

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Objectives: The present study aimed to compare the impacts of cognitive behavioral therapy (CBT) and behavioral treatment (BT) on weight loss and psychological outcomes among patients with three different subtypes of obesity: simple obesity, obesity with binge eating disorder, and obesity with depression.

Methods: Embase, PubMed, the Cochrane Central Register of Controlled Trials, Research Information Sharing Service, and Korean Studies Information Service System were systematically searched for randomized controlled trials conducted on or before May 2020, that used CBT to treat obesity. Methodological quality was assessed using Cochrane's risk of bias tool 2 and publication bias was evaluated through the funnel plot using the trim and fill method, Egger's test, and Begg and Mazumdar rank correlation test. A meta-analysis was conducted using a random-effects model and the standardized mean difference with 95% confidence interval (CI) was used to determine effect size.

Results: Twenty-one randomized controlled trials with a total of 22 intervention arms and 2,590 patients were included. Our study results revealed that the effects of CBT, compared with BT, on weight loss distinctly differed across all patient subgroups. In the simple obesity group, CBT was more effective than BT (Hedges' $g=0.138$, $CI=0.012\sim0.264$); however, in the obesity with binge eating disorder group, BT was more effective than CBT (Hedges' $g=-0.228$, $CI=-0.418\sim-0.038$); in the obesity with depression group, the effect of CBT was not statistically different from that of BT (Hedges' $g=0.276$, $CI=-0.307\sim0.859$). Further studies with larger sample sizes are required to confirm the outcomes observed in this study.

Conclusions: Our results indicated that the effects of CBT on obesity treatment vary based on patient subtype. Therefore, our findings suggest that CBT or BT should be selectively recommended as a treatment strategy for different obesity subtypes.

Key Words: Weight loss, Obesity, Cognitive behavioral therapy, Binge-eating disorder

INTRODUCTION

Worldwide, 39% of adults 18 years or older were overweight (body mass index [BMI] ≥ 25 kg/m²) and 13% were

considered to have obesity (BMI ≥ 30 kg/m²) in 2016¹⁾. If this trend continues, almost half of the world's adult population will be overweight or obese by 2030²⁾. Obesity is thought to be influenced by psychosocial and cultural fac-

tors, as well as by energy imbalance due to excess energy intake or a lack of energy expenditure^{3,4}). Obesity and psychological issues, such as binge eating disorders and depression are highly comorbid^{5,6}), and are bi-directionally associated⁷), although the strength of this association is greater when depression leads to obesity than visa-versa⁸). Therefore, to successfully treat obesity and prevent recurrent weight gains, psychological symptoms should be managed alongside weight loss. Behavioral treatment (BT) is an approach used to help individuals develop skills to improve their weight problem with three components: diet, physical activity, and behavioral therapy⁹). Cognitive behavioral therapy (CBT) is an intervention that combined with BT and cognitive approaches⁹); Cognitive approaches are aimed at modifying dysfunctional emotions, behaviors, and thoughts³). Therefore, CBT has the potential of being useful in obesity treatment to influence cognitions related to behavior change, including a low energy diet, high-activity lifestyle, and realistic expectations^{9,10}). It also assists patients to prevent possible relapses and manage critical situations with coping strategies⁴).

The comparative effects of CBT and BT on weight loss or psychological outcomes in obesity treatment have been assessed in previous studies; however, the results have varied for obesity subtypes. Peckmezian and Hay¹¹) stated that CBT and BT both led to weight loss with improvements in psychological aspects, such as cognitive restraint and binge eating, for uncomplicated obesity. However, there was no clear comparison of effect between CBT and BT. In a meta-analysis⁷), CBT was more effective than BT for weight loss, increasing cognitive restraint, and reducing emotional eating in a population that pooled together different categories of obesity patients, including those with simple obesity and obesity with depression. In meta-analyses for obesity with binge eating disorder, CBT produced greater reduction than BT in binge eating frequency without weight reduction¹²⁻¹⁴). However, the comparative effect of CBT in obesity with binge eating disorder remains unclear, since some previous results were obtained from a comparison with inactive interventions, such as a waitlist¹³) or comparison of

only one type of CBT intervention¹⁴). It was also more difficult to assess the effect of CBT in the obesity with depression group. Few studies have evaluated the effect of CBT in obesity with depression, since researchers have tended to exclude patients with depression from obesity treatment because of concerns regarding worsening of depressive symptoms during weight loss programs¹⁵).

Given prior work and gaps in the field, the present study aimed to compare the effects of CBT and BT on obesity treatment and to examine whether the effect size of CBT varies across obesity subtypes. The obesity subtypes in this study were classified as simple obesity, obesity with binge eating disorder, and obesity with depression. Since CBT is the intervention that focuses mainly on emotional, cognitive, and psychological issues^{3,9}), one could suppose that obese patients with psychological problems such as binge eating or depression may have different results than those with simple obesity. The obesity subtypes in this study were defined as follows: simple obesity is the overweight or obese condition without any severe physical or psychological comorbidities, obesity with binge eating disorder or obesity with depression is the overweight or obese condition fulfilling binge eating or depressive disorder criteria without severe physical comorbidities. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM)-5 criteria¹⁶), binge eating disorder is characterized by recurrent binge eating accompanied with lack of control over eating, consumption of an excessive amount of foods in a discrete period, and distress over binge eating, without inappropriate compensatory weight control methods observed in bulimia nervosa. Depression is characterized by the presentation of depressed mood and/or loss of interest for 2 weeks, plus at least four additional symptoms of unintended weight changes, appetite changes, insomnia or hypersomnia, psychomotor changes, fatigue, feelings of worthlessness, difficulty concentrating, or suicidal ideation¹⁶).

METHODS

1. Data sources and searches

A literature search was conducted using the following sources: Cochrane Central Register of Controlled Trials, PubMed, Embase, Research Information Sharing Service, and Korean Studies Information Service System, and included studies published in all journals on or before May, 2020. Additionally, reference lists from the selected studies, related studies, and grey literature were also searched. The search strategy followed the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA)¹⁷⁾ protocol. The search terms used were entered as keywords or Mesh terms where possible, and used in English and Korean: (“cognitive behav*” OR “CBT”) AND (“weight los*” OR “obesity treat*” OR “weight manage*” OR “weight control” OR “dieting”) AND (“obes*” OR “overweight*” OR “binge-eating” OR “depress*”). Two reviewers searched for articles independently, and discrepancies, if any, identified in the search results were resolved through mutual discussion.

2. Study selection (inclusion and exclusion criteria)

To evaluate the effects of CBT versus BT on various individuals suffering from obesity, clinical randomized controlled trials (RCTs) that compared the effect of CBT with that of BT on weight loss were analyzed. The eligible population included (1) adults over 18 years, (2) overweight or obese individuals ($BMI \geq 25 \text{ kg/m}^2$), and (3) those with no severe physical or psychological comorbidities other than binge eating disorder and depression criteria. In selected studies, binge eating and depression were diagnosed through a specialist’s interview according to the DSM -IV¹⁸⁻²²⁾, DSM-IV-TR²³⁾, DSM-5²⁴⁾ or Hamilton Depression Rating Scale (HDRS)¹⁵⁾ criteria. For our inclusion criteria, we required that a study on CBT interventions included at least one cognitive therapy (e.g. cognitive restructuring, body image acceptance, and problem-solving) beyond general behavioral therapy (e.g. self-monitoring, stimulus control, and goal setting)^{7,15)}. BT interventions included at least one of components: general behavioral therapy, diets (such as calo-

rie restriction and nutrition education), exercise, and physical activity. If usual care for weight loss contained any BT component, usual care also was included in BT intervention group.

We excluded the developed CBT studies such as third-wave CBT from our CBT criteria. Third-wave CBTs such as mindfulness-based cognitive therapy and dialectical behavioral therapy have recently been used for treating obesity^{25,26)}; however, these focus on the processes of acceptance, mindfulness, attention, or value²⁷⁾ that exceeds the traditional CBT criteria. We excluded studies comparing CBT with no treatment, pharmacological intervention treatment, or surgical treatment.

3. Data extraction and quality assessment

A predefined data template was prepared to compile data from the included studies. The two co-first authors independently extracted and coded the following data based on the template: Study characteristics (author, publication year, and journal), participants (sample size, age, gender, weight, and BMI), interventions (time period, type of intervention, and type of control), and outcomes (change in mean and standard deviation of body weight, depressive symptom scores, number of binge eating days/episodes, dietary restraint scores, and diet/exercise self-efficacy scores). The data were cross-checked by the two co-first authors and any discrepancies were discussed until an agreement was reached. The methodological quality of each included study was assessed using Cochrane’s risk of bias (RoB) tool 2²⁸⁾.

4. Calculating effect sizes

A meta-analysis uses statistical methods to synthesize effect size and standardize quantitative findings from a range of studies²⁹⁾. In the present study, we calculated effect sizes based on the standardized mean change difference (SMD) from pre- to post-treatment in both the intervention and control groups³⁰⁾. The SMDs were computed using the following formula:

$$g^t = \frac{Y^t - X^t}{S^y}, \quad g^c = \frac{Y^c - X^c}{S^y}$$

In this formula, Y^t and X^t are the post- and pre-treatment means of the intervention group, respectively, Y^c and X^c are the post- and pre-treatment means of the control group, respectively, and S^y is the post-test standard deviation of the intervention and control groups. The effect size corresponded to the SMDs using the following formula: $\Delta = g^t - g^c$. The estimated variance of the SMD (i.e. “Var (Δ)”) is defined as follow:

$$Var(\Delta) = Var(g^t) + Var(g^c) = \frac{4(1-r^t) + (g^t)^2}{2n^t} + \frac{4(1-r^c) + (g^c)^2}{2n^c}$$

In this formula, r^t and r^c are estimates of the pre- and post-treatment correlations in the intervention and control groups, respectively.

Small-sample studies tend to overestimate effect sizes. Thus, a small-sample correction factor (Hedges' g) involving SMD multiplied by a correction factor J , was used³¹⁾. This correction factor J was computed using the following formula:

$$J = 1 - \left(\frac{3}{4df-1} \right), \quad df = (n_1 + n_2 - 2)$$

The weighted mean difference with 95% confidence intervals was used to determine effect size. The meta-analysis was conducted using Comprehensive Meta-Analysis software (version 3.0; Biostat Inc., Englewood, NJ, USA).

5. Data analyses

A nutritionist, clinician, and meta-analytical statistician collaborated on all aspects of this study. The primary outcome was BMI (kg/m²) or body weight (kg) change. The secondary outcomes were changes in scores/numbers of depressive symptoms, binge eating, dietary restraint, diet self-efficacy, and exercise self-efficacy. Body weight changes were calculated as the differences between pre- and post-treatment mean body weights (kg) or percent of body weight reductions. Secondary outcomes included assessments using the following scales: binge eating was assessed using the

Eating Disorder Examination (EDE)^{19,20,23,24)}, or the Eating Disorder Examination-Questionnaire (EDE-Q)^{18,32)}, depressive symptoms using Beck's Depression Index (BDI)^{18,20,24,32,33)}, BDI-II^{22,34)}, HDRS¹⁵⁾, or Symptom Check List-20²¹⁾, dietary restraint was measured using the EDE-Q^{18,20,32,35)}, diet self-efficacy was assessed via the Weight Efficacy Lifestyle Questionnaire³⁶⁻³⁸⁾ or an adopted scale based on a measure developed by Bandura³⁹⁾, and exercise self-efficacy was assessed through the exercise self-efficacy scale^{36,40)}, or an adopted scale based on a measure developed by Bandura³⁹⁾. Participants were classified into three obesity subgroups: simple obesity, obesity with binge eating disorder, and obesity with depression, and the effect size of outcomes was compared between subgroups. Heterogeneity in primary or secondary outcomes between studies was assessed using Q test and I^2 ³¹⁾. This meta-analysis was conducted using a random-effect model to assess effect size since there was significant heterogeneity in the types of intervention, participants, and treatment period between studies. A funnel plot³¹⁾, Egger test⁴¹⁾, and Begg and Mazumdar rank correlation⁴²⁾ were performed to assess publication bias and to synthetically analyze all the results. Subgroup analysis was conducted on the weight measuring time point divided by ≤ 12 weeks or > 12 weeks. In obesity treatment studies, the difference between the time points of weight measurement is considered important given that it can affect the outcome.

RESULTS

1. Study description

The initial search compiled a total of 680 studies; 603 studies through databases and 77 studies through other sources. We initially screened articles using only the title and abstract; if these were insufficient for determining the appropriateness for inclusion, we then screened the full-text article. In addition, for data-insufficient studies, we contacted the corresponding authors requesting sufficient data to calculate the effect size, such as mean, standard deviation, and sample sizes; however, we received no response from any author. Ultimately, only 21 studies met the inclusion

Fig. 1. Preferred reporting items for systematic review and meta-analysis (PRISMA) flow diagram of identification, screening, eligibility, and inclusion process.

criteria and were assessed (Fig. 1). This included 22 intervention arms, one of which included two intervention arms, and a total of 2,590 participants. Studies were classified into three categories according to obesity subtypes: simple obesity (13 studies; $n=1,752$), obesity with binge eating disorder (5 studies; $n=423$), and obesity with depression (3 studies; $n=415$). The characteristics of the included studies and comparisons of intervention details between the intervention and control groups are shown in Tables 1 and 2, respectively.

2. RoB and publication bias

1) Quality assessment

The RoB assessment for the 21 studies included here is summarized in Fig. 2. The RoB was rated 'high' in

19^{10,15,18-24,32-36,38-40,43,44} and 'some concerns' in 2^{37,45}). In 16 studies^{10,15,18-24,32-36,40,45}, sequence generation or allocation concealment in the randomization process was not reported or was unclear. In all studies, blinding of one or both of the participants and assessors was not conducted or not mentioned. It is difficult to blind participants and assessors since RCTs involving CBT could not be placebo-controlled clinical trials. We increased the risk assessment rating if the imbalance of study interventions could be biased or if the self-reporting could be influenced.

2) Publication bias

No significant publication bias was observed on Begg and Mazumdar rank correlation ($P=0.797$) and on the Egger test ($P=0.775$). Moreover, symmetrical distribution was revealed on visual inspection of the funnel plots (Fig. 3). As

Table 1. Characteristics of Randomized Controlled Trials of Cognitive Behavioral Therapy

Author, Year	Population	Age (yr)	Female (%)	Initial BMI (kg/m ²) or BW* (kg)	Number of participants randomized	Total number analyzed	CBT intervention period (wk)	Type of intervention group	Type of control group	Outcomes
Tanco, 1998 ³³	Simple obesity	NR	100.0	39.5	42	37	8	CT	BT plus LED plus exercise	BMI, depression
Ramirez, 2001 ³⁵	Simple obesity	44.0	78.5	33.78	88	65	16	CT plus NE plus PA	BT plus NE plus PA	BW, restraint
Ames, 2005 ³⁴	Simple obesity	21.5	100.0	31.1	80	26	26	CT plus LED plus exercise	BT plus LED plus exercise	BW, depression
Stahre, 2007 ¹⁰	Simple obesity	48.6	100.0	100.3*	54	29	10	CT plus LED	Diet information and practice	BW
Beafort, 2008 ³⁹	Simple obesity	44.3	100.0	39.8	44	33	16	CT plus LED plus PA	BT plus LED plus PA	BMI, diet self-efficacy, exercise self-efficacy
Werrij, 2009 ³²	Simple obesity	45.0	81.0	33.4	200	200	10	CT plus NE	BT plus NE plus exercise	BMI, binge eating, depression, restraint
Rodriguez-Hernandez, 2009 ³⁶	Simple obesity	45.4	100.0	35.8	58	58	26	(1) CT plus LED (LF) plus exercise (2) CT plus LED(LC) plus exercise	(1) LED (LF) plus exercise (2) LED (LC) plus exercise	BMI
Annesi, 2010 ⁴⁰	Simple obesity	42.2	100.0	36.6	150	134	26	CT plus NE plus exercise	NE plus exercise	BW, exercise self-efficacy
Annesi, 2012 ³⁶	Simple obesity	42.5	82.6	41.7	430	430	26	CT plus CR plus exercise	NE plus exercise	BW, exercise self-efficacy, diet self-efficacy
Annesi, 2013 ³⁷	Simple obesity	43.4	80.6	40.3	324	324	26	CT plus CR plus exercise	NE plus exercise	BMI, diet self-efficacy
Jamal, 2016 ³⁸	Simple obesity	40.5	72.7	32.4	194	194	24	CT plus LED plus PA	CR plus PA	BMI, diet self-efficacy
Manzoni, 2016 ⁴³	Simple obesity	35.6	100.0	42.2	102	102	6	CT plus LED plus exercise	BT plus LED plus exercise	BW
Marcon, 2017 ⁴⁴	Simple obesity	46.3	89.7	48.3	44	39	16	CT plus exercise	BT plus exercise	BW
Grilo, 2005 ¹⁸	Binge eating	46	81.3	34.7	75	75	12	CT	BT	BMI, binge eating, depression, restraint
Munsch, 2007 ²³	Binge eating	45.9	88.8	36.5	80	80	16	CT	BT plus NE	BMI, binge eating
Wilson, 2010 ¹⁹	Binge eating	48.3	85.4	36.5	130	130	24	CT	BT plus CR plus exercise	BMI, binge eating
Grilo, 2011 ²⁰	Binge eating	44.8	67.0	38.8	90	90	24	CT	BT plus CR plus PA	BMI, binge eating, depression, restraint
Grilo, 2013 ²⁴	Binge eating	45.8	79.0	37.6	48	48	16	CT	BT	BMI, binge eating, depression
Linde, 2011 ²¹	Depression	52	100.0	39.5	203	203	26	CT plus LED plus exercise	BT plus LED plus exercise	BW, depression
Pagoto, 2013 ²²	Depression	45.9	100.0	35.4	161	161	26	CT plus CR plus exercise	BT plus CR plus exercise	BW, depression
Faulconbridge, 2018 ¹⁵	Depression	49.5	92.2	36.3	51	48	20	CT plus LED plus exercise	BT plus LED plus exercise	BW, depression

BMI: body mass index, BW: body weight, CBT: cognitive behavioral therapy, NR: not reported, CT: cognitive therapy, BT: behavioral therapy, LED: low energy diet, NE: nutrition education, PA: physical activity, LF: low fat diet, LC: low carbohydrate diet, CR: calorie restriction.

Table 2. Comparison of Intervention Details between Intervention and Control Groups

Author, year	Type of intervention	Type of control
Tanco, 1998 ³³⁾	<ul style="list-style-type: none"> CT therapeutic approaches based on cognitive principles, discussion regarding body ideals and appearances and encouraging to recognize psychological and physiological need 	<ul style="list-style-type: none"> Daily records of their food intake (1,200~1,500 kcal/d, daily food diaries) and exercise, reviewed weekly
Ramirez, 2001 ³⁵⁾	<ul style="list-style-type: none"> Cognitive restructuring to help them reduce negative self-talk and control self-defeating regarding appearances Homework assignment to listen to audiotapes to decrease appearance-related distress Nutritional and behavioral self-management program to promote eating and exercise change 	<ul style="list-style-type: none"> Nutrition and behavioral self-management program to promote eating and exercise change
Ames, 2005 ³⁴⁾	<ul style="list-style-type: none"> RCB intervention focused on establishing realistic weight goals and expectations for weight loss, correcting faulty assumptions regarding appearance, valuing aspects of self-unrelated to weight, and fostering acceptance of the weight and body shape achieved following treatment 	<ul style="list-style-type: none"> SB intervention: Low-calorie intake (e.g., 1,200~1,500 kcal/d) and training in self-monitoring, goal setting, stimulus control, social support, and relapse prevention strategies. Structured exercise consisting of 30 min of moderate to high intensity activities (e.g., aerobics classes, brisk walking, jogging, cycling) for 5 or more days per week
Stahre, 2007 ¹⁰⁾	<ul style="list-style-type: none"> Cognitive group treatment to inform the probable causes of dysfunctional eating behavior and to focus on deficiencies in self-control, low self-esteem, and stress LED: 1,200~1,300 kcal/d 	<ul style="list-style-type: none"> Information on dieting and practical training
Befort, 2008 ³⁹⁾	<ul style="list-style-type: none"> Motivational interviewing: changing behaviors by discussing past experiences, clarifying connections between core values and weight loss, as well as motivation to lose weight Decrease calorie intake by 500~1,000 kcal/d and increase physical activity to 150 min/wk 	<ul style="list-style-type: none"> Health education: Provision of health information and advice unrelated to weight loss Decrease energy intake by 500~1,000 kcal/d and increase physical activity to 150 min/wk
Werrij, 2009 ³²⁾	<ul style="list-style-type: none"> First intervention: Same as the control group Second intervention: Provided with workbooks containing background information on cognitive intervention and homework including thought diaries (changing dysfunctional cognitions concerning eating, control, weight, and shape) 	<ul style="list-style-type: none"> First intervention: Provided with nutritional education, food diaries, and learning when to stop eating, how to refuse food, how to find social support, and how to deal with parties, among others. Second intervention: Low intensity exercise program supervised by a physiotherapist
Rodriguez-Hernandez, 2009 ⁴⁵⁾	<ul style="list-style-type: none"> Behavioral strategies, cognitive skills, and relapse prevention techniques to identify factors that trigger overeating Exercise: Walking, dancing, cycling, or swimming for 30 min/d, for at least 5 d/wk LED-LF/LC (30 kcal/kg/d) 	<ul style="list-style-type: none"> Exercise: Walking, dancing, cycling, or swimming for 30 min/d, for at least 5 d/wk LED-LF/LC (30 kcal/kg/d)
Annesi, 2010 ⁴⁰⁾	<ul style="list-style-type: none"> Exercise support based on each participant's preference Cognitive behavioral method includes establishing caloric goals and logging daily food and calorie intake, regular self-weighing, cognitive restructuring, relapse prevention training, understanding cues to overeating, and relaxation strategies 	<ul style="list-style-type: none"> Exercise support based on each participant's preference Nutrition education include understanding carbohydrates, protein, fats, and calories, using the US Food Guide Pyramid, menu planning, and developing a plan for snacking
Annesi, 2012 ³⁶⁾	<ul style="list-style-type: none"> Exercise support based on each participant's preference (6, 1-hr individual sessions per week). Cognitive behavioral method included establishing caloric goals and logging daily food and calorie intake, regular self-weighing, cognitive restructuring, relapse prevention training, understanding cues to overeating, and relaxation strategies 	<ul style="list-style-type: none"> Exercise support based on each participant's preference (6, 1-hr individual sessions per week). Nutrition education included understanding carbohydrates, protein, fats, and calories, using the US Food Guide Pyramid, menu planning, and developing a plan for snacking
Annesi, 2013 ³⁷⁾	<ul style="list-style-type: none"> Exercise support instructing additional behavioral skills, such as productive self-talk, addressing cues to exercise, and accommodating barriers to exercise (six, 45~60 min/wk) Cognitive behavioral nutrition education establishing caloric goals and logging daily food and caloric intake, practicing restructuring, and leveraging cues to overeating 	<ul style="list-style-type: none"> Exercise support instructing additional behavioral skills such as productive self-talk, addressing cues to exercise, and accommodating barriers to exercise (six, 45~60 min/wk) Standard nutrition education, including understanding carbohydrates, protein, fats, and calories, and developing a plan for snacking
Jamal, 2016 ³⁸⁾	<ul style="list-style-type: none"> Cognitive behavior sessions regarding negative thoughts, challenges in lifestyle change, maintaining motivation, experience sharing Decrease caloric intake by 500 kcal/d Increase physical activity by 150 min/wk Trainers: Dietician, exercise specialist and psychologist 	<ul style="list-style-type: none"> Decrease caloric intake by 500 kcal/d Increase physical activity by 150 min/wk Trainers: dietician, exercise specialist

Table 2. Continued

Author, year	Type of intervention	Type of control
Manzoni, 2016 ⁴³⁾	<ul style="list-style-type: none"> Self-monitoring of food intake and eating patterns, addressing barriers to weight loss and body image concerns, and learning problems in eating, mood, and thinking patterns 	<ul style="list-style-type: none"> Low calorie diet (1,200 kcal/d) and physical training (minimum of 30 min of walking, twice a week)
Marcon, 2017 ⁴⁴⁾	<ul style="list-style-type: none"> Reduction or elimination of undesirable behaviors, negative thoughts associated with diet, and physical activity Exercise: 25 min, 2 times/wk 	<ul style="list-style-type: none"> Information regarding the importance of changing eating habits and physical activity Exercise: 25 min, 2 times/wk
Grilo, 2005 ¹⁸⁾	<ul style="list-style-type: none"> CBT self-help book including psychoeducational chapters (e.g., binge eating, associated problems, self-help approach) and how to change eating habits and associated features. 	<ul style="list-style-type: none"> Behavioral weight loss self-help book focused on lifestyle changes with goals of moderate caloric restriction and increased physical activity to produce modest gradual weight losses.
Munsch, 2007 ²³⁾	<ul style="list-style-type: none"> Education regarding treatment of binge eating, self-monitoring of eating behavior, daily food intake plan, body exposure training, and goal setting, regulating eating behavior, identifying binge eating cues, and modification body concept 	<ul style="list-style-type: none"> Understanding etiology and treatment of obesity, weight loss goals, fat reduced nutrition, and increasing physical activity Self-monitoring of fat intake, stress related eating, and identifying and coping with risk situations
Wilson, 2010 ¹⁹⁾	<ul style="list-style-type: none"> Education on binge eating and focus on self-monitoring, self-control, problem solving, and relapse prevention. 	<ul style="list-style-type: none"> Self-monitoring of exercise, fat intake, and caloric intake. 2.5 hours of moderate exercise/week
Grilo, 2011 ²⁰⁾	<ul style="list-style-type: none"> Identifying and challenging maladaptive cognitions regarding eating and weight/shape, and thoughts that serve as binge eating triggers 	<ul style="list-style-type: none"> Focused on making gradual lifestyle changes Moderate caloric restriction Increase in physical activity
Grilo, 2013 ²⁴⁾	<ul style="list-style-type: none"> Education regarding binge eating, dieting, and health; development of coping skills for maladaptive eating triggers 	<ul style="list-style-type: none"> Advice and treatment recommendation by primary care physician
Linde, 2011 ²¹⁾	<ul style="list-style-type: none"> Setting of additional behavioral and cognitive change-related goals to improve depressive symptoms, and regular mood self-monitoring (55% for depression treatment + 45% for weight loss treatment) LED: 1,200~1,500 kcal/d Exercise: Increase physical activity until 2,500 kcal/wk 	<ul style="list-style-type: none"> Focus on behavioral goal setting and self-monitoring of caloric intake, physical activity, body weight LED: 1,200~1,500 kcal/d Exercise: Increase physical activity until 2,500 kcal/wk
Pagoto, 2013 ²²⁾	<ul style="list-style-type: none"> Improvements in thoughts, mood, and overall quality of life CR to lose weight 0.5~1 kg/wk Exercise: 30 min, 5 d/wk 	<ul style="list-style-type: none"> Health education on topic of women's health CR to lose weight 0.5~1 kg/wk Exercise: 30 min, 5 d/wk
Faulconbridge, 2018 ¹⁵⁾	<ul style="list-style-type: none"> Identify and modify negative automatic thoughts and core beliefs Cognitive restructuring, encouraged to use dysfunctional thought records LED: 1,200~1,300 kcal/d Exercise: Increase exercise to 180 min/wk 	<ul style="list-style-type: none"> Behavioral weight management skills, encouraged to record food intake and minutes of physical activity, self-monitoring, and stimulus control LED: 1,200~1,300kcal/d Exercise: Increase exercise to 180 min/wk

CT: cognitive therapy, RCB: reformulated cognitive-behavioral, SB: standard behavioral, LED: low energy diet, LF: low fat diet, LC: low carbohydrate diet, CBT: cognitive behavioral therapy, CR: calorie restriction.

we synthetically analyzed all the results, including the funnel plot, rank correlation, and Egger test, publication bias was not indicated. A non-significant tau does not prove the absence of bias since the power of the Egger test was low, unless there was severe bias or a substantial number of studies⁴⁶⁾. As a sensitivity analysis, we also assessed the trim and fill method on the impact of the small study effect.

3. Effects on obesity subtypes

Effects of CBT versus BT on different categories of individuals with obesity are summarized in Table 3.

1) Effects of CBT compared with BT in the simple obesity group

In the simple obesity group, the weight loss effect of CBT was significantly greater than BT even though the effect size was low (Fig. 4). Among the psychological outcomes, only the diet self-efficacy effect of CBT was statistically significant. The effects of CBT on depressive symptoms, binge eating, dietary restraint, and exercise self-efficacy were statistically insignificant compared to that of BT (Fig. 4).

The results of the subgroup analysis revealed that compared with BT, the effect of CBT on weight loss in the group ≤ 12 weeks ($n=4$) was not significantly different

Fig. 2. Quality assessment using Cochrane collaboration risk of bias tools in the included studies.

(Hedges' $g=0.038$; $CI=-0.166\sim0.243$), but in the group >12 weeks ($n=10$), the effect of CBT was higher than that of BT (Hedges' $g=0.158$; $CI=0.050\sim0.266$). Differences between the weight measurement time points affected CBT's influence on weight loss. The subgroup analysis was conducted only in the simple obesity group since the other groups had few studies for conducting subgroup analysis.

2) Effects of CBT compared with BT in the obesity with binge eating disorder group

In the obesity with binge eating disorder group, the ef-

fects of CBT and BT were different for each outcome. CBT had a significantly favorable effect on reducing binge eating, while BT had a significant beneficial effect on reducing body weight and improving dietary restraint. The effects of CBT and BT on depressive symptoms was not significantly different (Fig. 4).

3) Effects of CBT compared with BT in the obesity with depression group

In the obesity with depression group, no significant differences in weight loss and depressive symptoms were ob-

Fig. 3. A funnel plot of the effect size of body weight or body mass index changes between the cognitive behavioral therapy and behavioral treatment groups.

Table 3. Effect Size of Cognitive Behavioral Therapy by Subtypes on Obesity Treatment for Weight Loss and Psychological Outcomes

Subgroup	Effect size (Hedges' g), 95% confidence interval, and number of intervention arms					
	Weight loss	Depressive symptoms	Binge eating	Dietary restraint	Diet self-efficacy	Exercise self-efficacy
Simple obesity	0.138 (0.012, 0.264) (N=14)	0.138 (-0.162, 0.439) (N=3)	0.260 (-0.018, 0.537) (N=1)	-0.287 (-0.595, 0.022) (N=2)	0.187 (0.000, 0.374) (N=4)	0.029 (-0.207, 0.265) (N=3)
Obesity with binge eating disorder	-0.228 (-0.418, -0.038) (N=5)	0.072 (-0.194, 0.337) (N=3)	0.204 (0.014, 0.394) (N=5)	-0.307 (-0.611, -0.003) (N=2)	-	-
Obesity with depression	0.276 (-0.307, 0.859) (N=3)	0.008 (-0.571, 0.587) (N=3)	-	-	-	-
Overall	0.059 (-0.056, 0.174) (N=22)	0.093 (-0.091, 0.277) (N=9)	0.218 (0.002, 0.434) (N=6)	-0.310 (-0.574, -0.046) (N=4)	0.187 (0.000, 0.374) (N=4)	0.029 (-0.207, 0.265) (N=3)

served between CBT and BT groups (Fig. 4).

DISCUSSION

This meta-analytic approach compared CBT to BT for obesity and divided patients into subgroups, including simple obesity, obesity with binge eating disorder, and obesity

with depression. Our primary findings indicated that compared with BT, the effect of CBT on weight loss distinctly differed across all patient subgroups. Our subgroup assessment demonstrated that CBT, compared with BT, was effective in promoting weight loss in simple obesity, but in obesity with binge eating disorder, BT was more effective in promoting weight loss than CBT. Moreover, in obesity with

Fig 4. Forest plot of cognitive behavioral therapy effect compared with behavioral treatment in simple obesity group, obesity with binge eating disorder group, and obesity with depression groups.

depression, there was no statistically significant difference between CBT and BT to reduce body weight. The effects of CBT and BT were different for each psychological outcome in each obesity subtype. In simple obesity, among the psychological outcomes, only the diet self-efficacy effect of CBT was statistically significant and the effects of CBT on depressive symptoms, binge eating, dietary restraint, and exercise self-efficacy were statistically insignificant than that of BT. In obesity with binge eating disorder, CBT had a significantly favorable effect on reducing binge eating. And in obesity with depression, no differences in the depressive symptoms were observed between CBT and BT groups.

Jacob et al.⁷⁾ systematically reviewed studies that examined the effect of CBT weight loss interventions and psychological outcomes (cognitive restraint, emotional/binge eating, and depressive/anxiety symptoms) in adults who were overweight or obese, and reported that in addition to weight loss, CBT is an effective therapy for increasing cognitive restraint and reducing emotional eating; this supports our findings in simple obesity. However, in our study, CBT's effect on weight loss was low, which might be attributed to the fact that we evaluated the comparative effect between CBT and BT only with active treatment. The small effects or non-significant differences between treatments do not imply a lack of significant positive effects^{14,47-49)}. Since both treatments produce significant effects, the results do not reflect superiority in comparisons across the various treatments¹⁴⁾. CBT and BT both lead to weight loss during obesity treatment¹¹⁾ and indeed, all included studies reported significant weight reduction from baseline levels in CBT and BT groups. Moreover, even though the primary aim of several studies^{32-37,39,40,43)} on simple obesity was to change psychological aspects or to prevent relapse, rather than weight loss, the result of our meta-analysis revealed that CBT is more effective for weight loss than BT. This implies that CBT may sufficiently affect both weight loss and psychological outcomes in simple obesity.

In obesity with binge eating disorder, CBT had a superior effect only on binge eating, similar to previous studies¹²⁻¹⁴⁾, although we compared with only active control. BT pro-

duced weight loss accompanied by an increase in dietary restraint¹⁸⁻²⁰⁾. This could be explained by the fact that CBT in obesity with binge eating disorder primarily focused on the reduction of binge eating, while BT aimed at behavioral changes, including caloric restriction or increased physical activity.

In cases of obesity with depression, the effects on weight loss and depressive symptoms were not meaningfully different between the CBT and BT groups. Both cognitive or behavioral therapy for weight loss improved depressive symptoms. Since involvement in active treatment may also influence mood among patients with depression⁵⁰⁾, the type of treatment, whether CBT or BT, might not be important. We can also speculate that a small sample size can produce unimpressive P-values⁴⁸⁾, because of the small number of studies investigating obesity with depression.

1. Limitations

This study had several limitations. First, the number of studies classified into subgroups was small; thus, the comparison of outcomes between subgroups was limited, and even in simple obesity, the frequency of binge eating was assessed in only one study. Although we used the Hedges' g method and Egger test to overcome the bias from a small number of studies, it remains a limitation of this study. Further studies with larger sample sizes are required to confirm the outcomes observed in this study. Second, obesity with binge eating disorder or depression tends to accompany other psychological conditions, and binge eating disorder in particular has a high comorbidity rate⁵¹⁾. The selected study also included individuals with other psychological complications if not severe. In addition, the selected studies had heterogeneity at a measurement time point between 8 and 26 weeks. Therefore, it is necessary to interpret these results more carefully and apply them cautiously. Third, we limited the CBT criteria to the traditional CBT. Therefore, we could miss effective CBT interventions for obesity with binge eating disorder or depression. Lastly, research registration is recommended for systematic reviews based on the PRISMA reporting standard⁵²⁾, but this study

was not registered.

2. Suggestions for future research

We suggest that further research should expand to all psychological interventions to identify appropriate interventions for each obesity subtype, such as third-wave CBT beyond the traditional CBT. Additionally, the prevalence of comorbidities with other psychological problems among individuals with obesity and binge eating disorder or depression was high, and the number of studies in these groups was small. Therefore, to determine the clear effect of CBT in these populations, more RCTs with well-defined participants are required. It may also be possible to synthesize qualitative research or conduct network meta-analysis to obtain clear results regarding the effect of CBT in treating obesity.

CONCLUSIONS

Our study concluded that compared with BT, the effect of CBT on weight loss distinctly differed across all patient subgroups. Our subgroup assessment revealed that compared with BT, CBT was effective in promoting weight loss in simple obesity; however, in obesity with binge eating disorder, BT was more effective in promoting weight loss than CBT. In obesity with depression, the effect of CBT on weight loss was not statistically different from that of BT. The results also indicated that the effects of CBT and BT varied for each psychological outcome in each subgroup. Therefore, our findings suggest that CBT or BT should be selectively recommended as a treatment strategy for different obesity subtypes.

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