

Effectiveness of worksite-based dietary interventions on employees' obesity: a systematic review and meta-analysis

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BACKGROUND/OBJECTIVES: This study was designed to provide scientific evidence on the effectiveness of worksite-based dietary intervention to reduce obesity among overweight/obese employees.

MATERIALS/METHODS: Electronic search was performed using Ovid Medline, Embase, Cochrane Library, and CINAHL databases. The keywords used were "obesity," "nutrition therapy," and "worksite." The internal validity of the randomized controlled trials (RCTs) was assessed using the Cochrane's Risk of Bias. Meta-analysis of selected studies was performed using Review Manager 5.3.

RESULTS: A total of seven RCTs with 2,854 participants were identified. The effectiveness of dietary interventions was analyzed in terms of changes in weight, body mass index (BMI), total cholesterol, and blood pressure. The results showed that weight decreased with weighted mean difference (WMD) of -4.37 (95% confidence interval (CI): -6.54 to -2.20), but the effectiveness was statistically significant only in short-term programs < 6 months ($P=0.001$). BMI also decreased with WMD of -1.26 (95% CI: -1.98 to -0.55), but the effectiveness was statistically significant only in short-term programs < 6 months ($P=0.001$). Total cholesterol decreased with WMD of -5.57 (95% CI: -9.07 to -2.07) mg/dL, demonstrating significant effectiveness ($P=0.002$). Both systolic (WMD: -4.90 mmHg) and diastolic (WMD: -2.88 mmHg) blood pressure decreased, demonstrating effectiveness, but with no statistical significance.

CONCLUSIONS: The worksite-based dietary interventions for overweight/obese employees showed modest short-term effects. These interventions can be considered successful because weight loss was below approximately 5-10 kg of the initial body weight, which is the threshold for the management of obesity recommended by the Scottish Intercollegiate Guideline Network (SIGN).

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INTRODUCTION

Currently, obesity is a health condition that threatens people's health worldwide and the World Health Organization (WHO) presented a warning report showing that global obesity rates have nearly doubled since the 1980s [1]. According to the Centers for Diseases Control and Prevention [2], the prevalence of obesity in the U.S. population under 20 years old was below 10%, whereas that of adults over 20 years old increased by 15.5% in the past twenty years (from 22.3% in 1988-94 to 37.9% in 2013-14); it increased by 15.8% (from 54.9% in 1988-94 to 70.7% in 2013-14) when including the prevalence of overweight. WHO also reported that as of 2014, 39% of the world population over 18 years old were overweight, and 13% of them were obese. Overweight and obesity consist the fifth major risk factor for global deaths, and at least 2.8 million people die annually due to the overweight or obesity epidemic [1,3]. Therefore,

obesity has become a life-threatening condition. Fortunately, however, it can be prevented and treated.

Compared with other age groups, the prevalence of obesity among adults, who consist mainly of a working population actively engaged in economic activities, has grown rapidly and has been highlighted as a major public health concern [4,5]. It is known that employees' obesity not only raises the medical expenses but also has socio-economic consequences including low productivity, absenteeism from work, sick leave, disability, and injuries [6]. A study from Park *et al.* examining the correlation between obesity and employment characteristics, which included 15,121 employed adults using data from the National Health Interview Survey collected during a 10-year period, stressed the urgency for intensive interventions at worksites to support healthy choices and control obesity and consequent risks of relevant diseases [7].

Employees spend a considerable amount of time in their

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worksites. Therefore, worksite-based health intervention programs have the potential to systematically reach a large number of target individuals through already established formal or informal communication channels within the working environment [8]. Moreover, worksites offer opportunities for fostering social and organizational support that encourage healthy behaviors and disseminate positive effects of the programs through employees' families or social networks [9].

Obesity is caused by an imbalance between energy intake and expenditure. In this regard, controlling dietary intake has been consistently highlighted as one of the crucial factors in preventing and treating obesity [10,11]. A number of research publications have demonstrated the efficacy of worksite-based dietary interventions on obesity [12-14] and currently, it is imperative to determine the effects of these interventions. Therefore, the present study aimed to perform a systematic review and meta-analysis to provide scientific evidence, based on data from randomized controlled trials (RCTs), regarding the effectiveness and significance of worksite-based dietary intervention as a way to reduce obesity among overweight/obese employees.

MATERIALS AND METHODS

The present study followed the Cochrane Handbook for Systematic Reviews of Interventions [15] and the guidelines for systematic literature review presented by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses [16].

Search strategies

For electronic database search, the following search engines were used: Ovid Medline, Embase, Cochrane Library, and CINAHL Complete. For literature review, search strategies were established and tested prior to performing the search on September 23rd, 2016. Another search was performed on July 13th, 2017, to identify new studies. Also, the reference lists of all relevant articles were searched manually to identify further relevant studies. A systematic search of Google Scholar was used to explore the gray literature. For search keywords, the following MeSH terms were used: "obesity", "overweight", "nutrition therapy", "health promotion", and "workplace." Search filter from the Scottish Intercollegiate Guidelines Network (SIGN) was used on Ovid Medline for literature search regarding RCTs [17]. The combinations of search terms used are shown in Table 1.

Eligibility criteria

Searched literature was selected based on the following criteria: (i) type of studies: RCTs; (ii) type of participants: employees, who were overweight or obese, over 18 years of age with a body mass index (BMI) above 25 kg/m² [18] employees, who had diabetes or high blood pressure, but with regular work ability, were not excluded; (iii) type of intervention: dietary intervention programs that restricted intake of energy and/or certain nutrients such as carbohydrates and fats or that provided balanced intake of energy and relevant nutrients; (iv) comparators: just provision of nutrition consultation or educational materials, or no treatment; and (v) type of outcome

Table 1. Search strategy used for Ovid Medline

No.	Search term
1	Obesity/
2	Obesity, Morbid/
3	Obesity, Abdominal/
4	exp Overweight/
5	overweight/
6	Weight Loss/
7	(adipos* or obes*).tw.
8	(overweight* or over weight*).tw.
9	(weight adj1 (reduc* or los* or control* or manage*).tw.
10	weight.tw.
11	or/1-10
12	exp Workplace/ or workplace.mp.
13	work location.mp.
14	(work adj1 site).tw.
15	(job adj site*).tw.
16	occupational health.mp. or exp Occupational Health/
17	or/12-16
18	health promotion.mp. or exp Health Promotion/
19	nutrition therapy.mp. or exp Nutrition Therapy/
20	nutrition policy.mp. or exp Nutrition Policy/
21	nutrition intervention.mp.
22	nutrition program.mp.
23	diet therapy.mp. or exp Diet Therapy/
24	dietary change.mp.
25	exp Diet/
26	diet combination.mp.
27	healthy eating.mp.
28	healthy diet.mp.
29	food service.mp. or exp Food Services/
30	((diet or food or nutrition) and support).tw.
31	healthy food environment.mp.
32	or/18-31
33	11 and 17 and 32
34	Search filter of SIGN for randomized controlled trials
35	33 and 34

measures: weight loss, BMI change, total cholesterol change, and systolic/diastolic blood pressure change.

Literature was excluded based on the following criteria: (i) non-original studies; (ii) employees under 18 years of age; (iii) adult employees with BMI below 25.0 kg/m²; (iv) people with obesity with BMI over 25.0 kg/m² who were not at a worksite; (v) pregnancy or other health conditions that could affect nutrition absorption; (vi) intervention programs that offered only information on diet or nutrition, or that used commercialized diet programs; (vii) non-dietary intervention programs; (viii) literature that did not report relevant research results; and (ix) non-randomized study design. Language options were not restricted.

Study selection and data extraction

First, duplicate search results were eliminated. Then, the title and abstract of each result were reviewed. In cases that a clear decision was not feasible based on the title and abstract, the

full text was examined and selected based on the inclusion and exclusion criteria. For data extraction, generation of an evidence table was used to investigate the relevance. From the selected literature, the following data were extracted: type of randomized controlled trials, research location, utilization of randomized allocation method, concealment and blinding, inclusion criteria for research location and research participants, age, sex, BMI, dietary intervention program, and research outcome. All procedures were independently performed by two reviewers, and the final selection was made based on consensus. Any disagreements were resolved by third party involvement.

Risk of bias assessment

The quality of the selected studies was independently assessed by the two reviewers using Cochrane's Risk of Bias (RoB). This method consists of questions that assess seven domains of potential risk of bias as follows: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and other potential sources of bias that challenges validity. In addition, each domain is categorized into 3 levels based on the described content in each study: high risk of bias, low risk of bias, and unclear risk of bias. Each domain includes one or more specific entries, this is achieved by answering a pre-specified question about the adequacy of the study in relation to the entry. A judgement of 'Yes' indicates low risk of bias, 'No' indicates high risk of bias, and 'Unclear' indicates unclear or unknown risk of bias [15].

Statistical analysis

Meta-analysis was performed on the selected articles using Cochrane Review Manager 5.3 program (RevMan, Copenhagen, Denmark). Because the estimated effects are continuous variables, they were described in terms of weighted mean differences (WMD) and 95% confidence intervals (CI), and analyzed using the random-effect model. Mean differences and standard deviations before and after interventions or means and standard deviations of final values between experimental groups and control groups were used for meta-analysis. The overall effect and 95% confidence interval of outcome variables were analyzed using the general inverse variance estimation method. Confidence interval was used to derive standard deviation in studies that only reported means and confidence interval. As a conversion tool, the calculator on the Review Manager 5.3 program was used. In addition, pounds (lb.) were converted to kg to standardize the measurement units. The difference in effectiveness between groups was analyzed at 5% significance level. A forest plot was initially used to visually identify any overlapping areas between confidence interval and estimated effectiveness, and then Cochrane's Q statistics and Higgin's I^2 statistics were used to assess heterogeneity among various studies. The criteria for categorizing I^2 are as follows: $I^2 \leq 25\%$ was interpreted as low heterogeneity; $25\% < I^2 \leq 75\%$ as modest heterogeneity; and $I^2 > 75\%$ as high heterogeneity [15]. Publication bias was identified using funnel plots. Further, the results of the meta-analysis were divided and compared according to the different program durations, which were shorter than 6 months and longer than 6 months.

RESULTS

Description of included studies

A total of 467 studies were found in electronic databases. Among them, 428 studies were found during the search in 2016: 161 studies from Ovid-Medline; 135 from Embase; 55 from Cochrane Library; and 77 from CINAHL. During the search in 2017, 39 additional studies were found: 38 from the targeted search engines and one from Google Scholar. The number of duplicates was 143. After duplicates were excluded, 324 studies were examined based on the inclusion and exclusion criteria. First, the title and abstract of each study were examined and full-text assessment was performed on 52 studies. Ultimately, 317 studies (97.8%) were excluded, and seven studies were selected for review [19-25]. The process of study selection is presented in detail in Fig. 1.

Methodological quality of the included studies

None of the seven selected studies showed a high risk of bias, regarding methodological quality. Among the selected RCTs, four studies were cluster-RCTs [19,21-23]. Except for one study [25] that used random allocation, all studies were concealed using one of the following methods: randomization table, sealed envelope, or random order of numbers generated by computers. Only one study [22] used the blinding method, and blinding was applied to the test manager. During the follow-up period after the intervention, dropout rate did not exceed 20% in any study. Although one study [19] had a total dropout rate of 11.7%, but it did not exceed 20%. In addition, the study was a large scale randomized design of more than 1,000 subjects and therefore did not assess the low risk of bias in the selective outcome reporting. There was no disagreement between the reviewers on the quality of the included studies. The results are shown in Fig. 2.

General characteristics of selected studies

A total of seven studies were selected for evidence evaluation, and the total number of participants was 2,854. Among the selected studies, three [19-21] were conducted in the U.S., two in Denmark [22,23], one in the U.K. [24] and one study in Australia [25]. The average age of the participants was between 40 and 49 years, except for one study [25]. The average BMI was 30-34.99 kg/m², which is categorized as class I obesity, and none of the studies included participants who were pre-obese, with an average BMI between 25 and 30 kg/m². The dietary intervention programs offered to the participants were rather diverse. None of the interventions offered short-term diet programs (1-2 weeks) applying one-food diet; all interventions were long-term programs that reinforced maintaining stable calorie intake and the balanced nutritional intake. Among them, three studies offered a program limiting calorie intake [22-24]; three studies offered a low-fat program [19,20,25]; and one study offered a low carbohydrate program [21]. The programs in two studies lasted for 3 months [22,23]; the program in one study lasted for 18 weeks [20]; the programs in three studies lasted for 6 months [19,21,25]; and the program in one study [22] was implemented over a period of 12 months, which was comparatively long (Table 2).

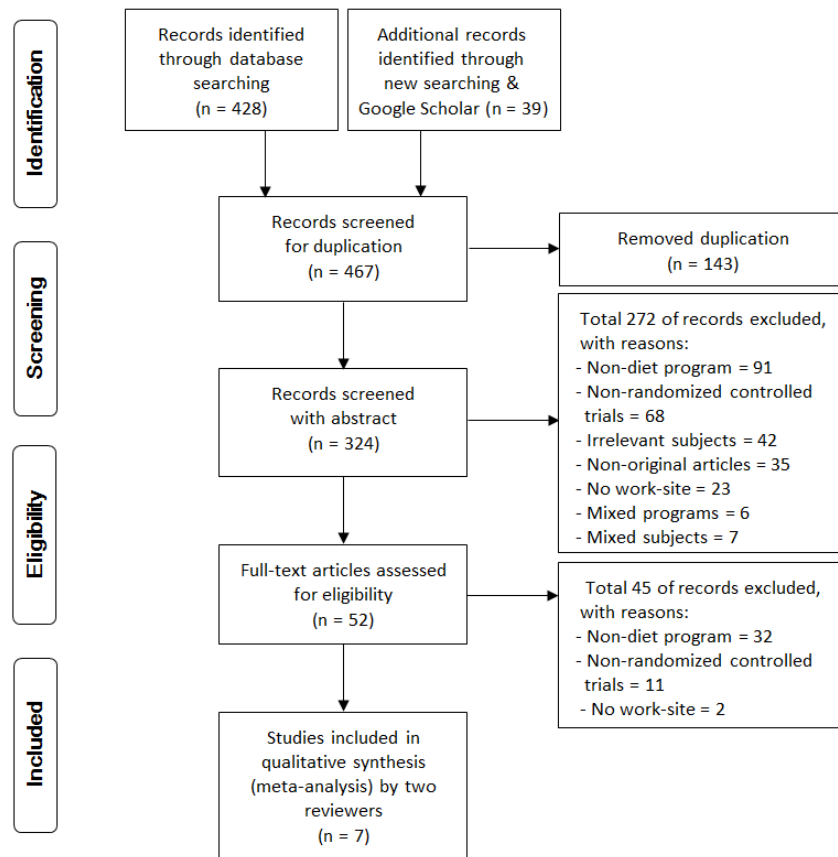
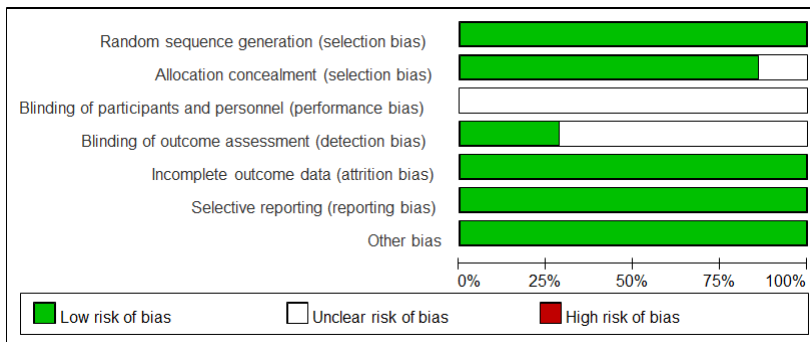


Fig. 1. Flow diagram of study selection

(A) Risk of bias graph



(B) Risk of bias summary

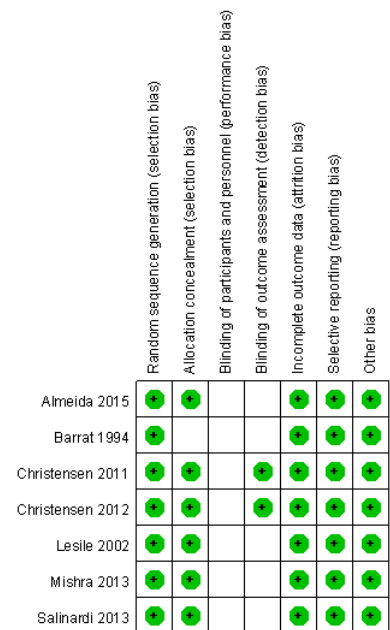


Fig. 2. The results of risk of bias

Table 2. Characteristics of the selected studies

First author	Year	Country	Type of study (concealment)	Participants					Follow up (mo) ²⁾	Interventions	Outcomes	
				Inclusion criteria	Group	Total (n)	Analysis (n)	Age (mean ± SD) ¹⁾				BMI (mean ± SD)
Almeida <i>et al.</i>	2015	USA	Cluster RCT ³⁾ (randomization table)	Worksite: work size 100-600 employees	Con. ⁵⁾	789	679	48.2 ± 2.8	33.3 ± 6.4	6	Less-intensive intervention INCENT ⁷⁾ program: diet and regular PA ⁸⁾ e.g., 150 min of PA/week Healthful diet: low fat, high fiber, emphasis on fruits and vegetables, choose water instead of sugar drinks for 6 mo	- Weight loss - BMI change - Total cholesterol change
				Participants: adults (> 18 years old) have a BMI ⁴⁾ ≥ 25 kg/m ²	Exp. ⁶⁾	1,001	902	45.7 ± 3.3	33.4 ± 6.4			
Mishra <i>et al.</i>	2013	USA	RCT (random number table)	Worksite: 10 GEICO ⁹⁾ corporate offices	Con.	149	149	46.1 ± 13.6	35.3 ± 0.7	4.5	No dietary change Low-fat vegan diet consisting of whole grains, vegetables, legumes, and fruits, with no restriction on energy intake for 18 weeks; and to take a daily supplement of vitamin B ₁₂	- Weight loss - BMI change - Total cholesterol change - Blood pressure change
				Participants: > 18 years of age with a BMI 25 kg/m ² and a previous diagnosis of type 2 diabetes	Exp.	142	142	44.3 ± 15.3	34.7 ± 0.6			
Salinardi <i>et al.</i>	2013	USA	Cluster RCT (random order of numbers)	Worksite: had not hosted a weight loss program during the past 6 mo;	Con.	34	34	49.9 ± 2.1	33.3 ± 1.2	6	Wait-listed control Group-weight loss program to achieve a weight loss of 0.5-1.0 kg/week through a lifestyle modification program; ≥40 g dietary fiber/day and had a low glycemic load; Macronutrient targets were 25% protein, 27% fat, and 48% low-glycemic index carbohydrates	- Weight loss - BMI change - Total cholesterol change - Blood pressure change
				Participants: ≥ 21 years of age, BMI ≥ 25 kg/m ² and a letter from the primary care physician with approval for weight loss	Exp.	84	84	48.6 ± 1.2	33.3 ± 0.7			
Christensen <i>et al.</i>	2012	Denmark	Cluster single-blinded RCT (sealed envelope)	Worksite: at least 50 health care workers with a minimum employment of 15 hours/week; Participants: female and	Con.	44	44	46.0 ± 8.6	30.4 ± 4.9	12	Two-hour oral lecture FEMALE program: the first part (0-3 mo) focused on weight loss and the second part (3-12 mo) focused on weight loss maintenance; calorie amount was lowered in steps of 300 kcal a day and strengthening exercises (15 min/hour)	- Weight loss - BMI change - Blood pressure change
				BMI > 25 kg/m ² or having body fat % > 33 (age 18-40 years) or > 34 (age > 40 years)	Exp.	54	54	45.7 ± 8.7	30.5 ± 5.4			
Christensen <i>et al.</i>	2011	Denmark	Cluster single-blinded RCT	(as above the same)	Con.	44	44	46.0 ± 8.6	30.4 ± 4.9	3	Two-hour oral lecture FEMALE program	- Weight loss - BMI change - Blood pressure change
					Exp.	54	54	45.7 ± 8.7	30.5 ± 5.4			
Leslie <i>et al.</i>	2002	UK	RCT (blind envelope)	Worksite: a large industrial work-site	Con.	44	44	41.3 ± 8.1	31.5 ± 3.7	3	Energy deficit diet; reduce 600 kcal from each individual's estimated Generalized low-calorie diet 1,500 kcal eating plan; both groups was designed to provide greater than 50% energy from carbohydrate, < 35% from fat and < 20% from protein	- Weight loss - BMI change
				Participants: 18-55 years volunteers with BMI > 25 kg/m ²	Exp.	42	42	42.1 ± 7.8	30.4 ± 3.7			
Barratt <i>et al.</i>	1994	Australia	RCT	BMI > 25 kg/m ² overweight and	Con.	259	259	36.8 ± 11.5		6	Screening only Dietary intervention; reduce total and saturated fat and increase fiber intake	- Total cholesterol change
				BMI > 30 kg/m ² obese	Exp.	114	114					

¹⁾ SD: standard deviation²⁾ mo: months³⁾ RCT: randomized controlled trial⁴⁾ BMI: body mass index⁵⁾ Con.: control group⁶⁾ Exp.: experimental group⁷⁾ INCENT: internet-based intervention with monetary incentives⁸⁾ PA: physical activity⁹⁾ GEICO: the government employees insurance company

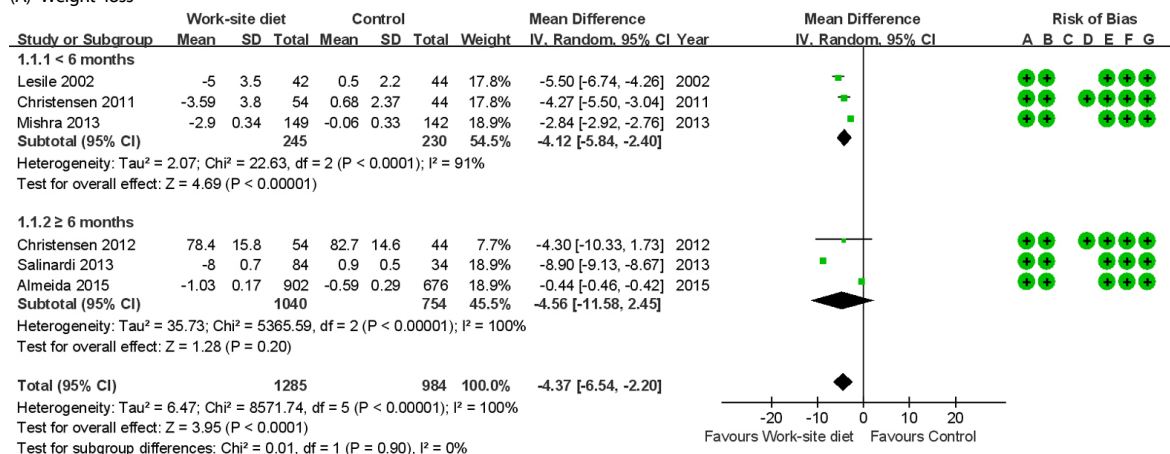
Effects of dietary intervention programs on weight loss

Six studies demonstrated a weight loss effect (Fig. 3A). The meta-analysis showed that the weight decreased with WMD of -4.37 (95% CI: -6.54 to -2.20) kg, which was statistically significant ($Z = 3.95, P < 0.001$).

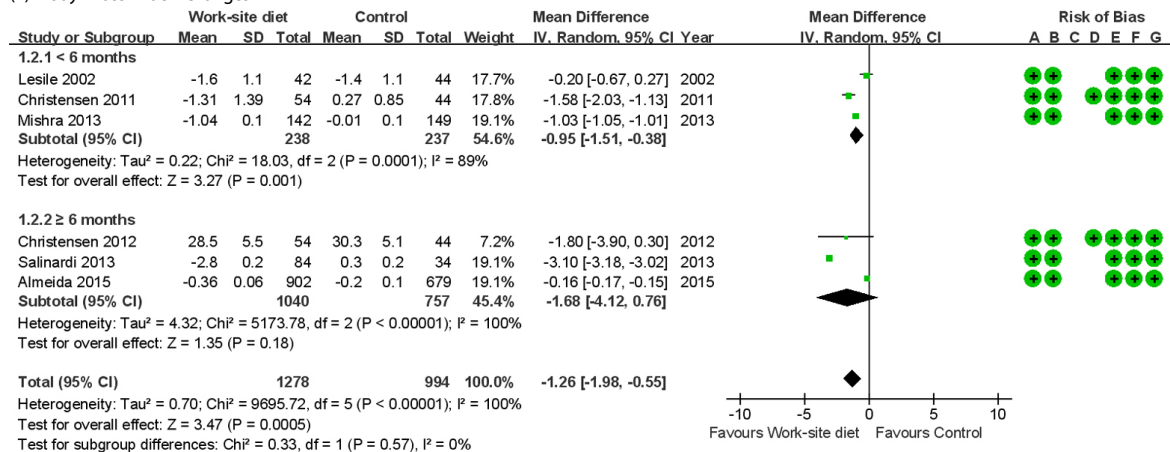
Additional analysis considering different program durations

demonstrated a statistically significant ($Z = 4.69, P < 0.001$) decrease in weight with WMD of -4.12 (95% CI: -5.84 to -2.40) kg, in programs shorter than 6 months. Programs longer than 6 months also showed a decrease with WMD of -4.56 (95% CI: -11.58 to 2.45) kg, but it was not statistically significant ($Z = 1.28, P = 0.20$). The heterogeneity among studies was high in

(A) Weight loss



(B) Body mass index changes



(C) Total cholesterol changes

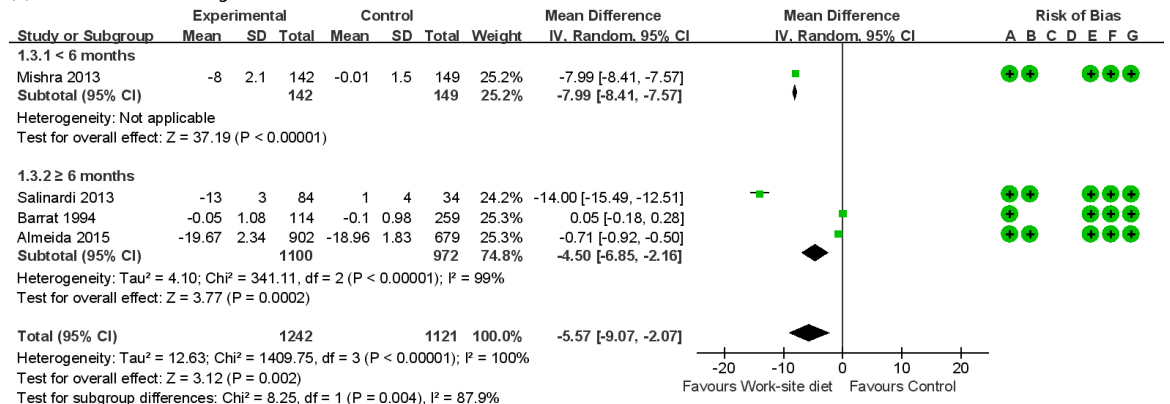
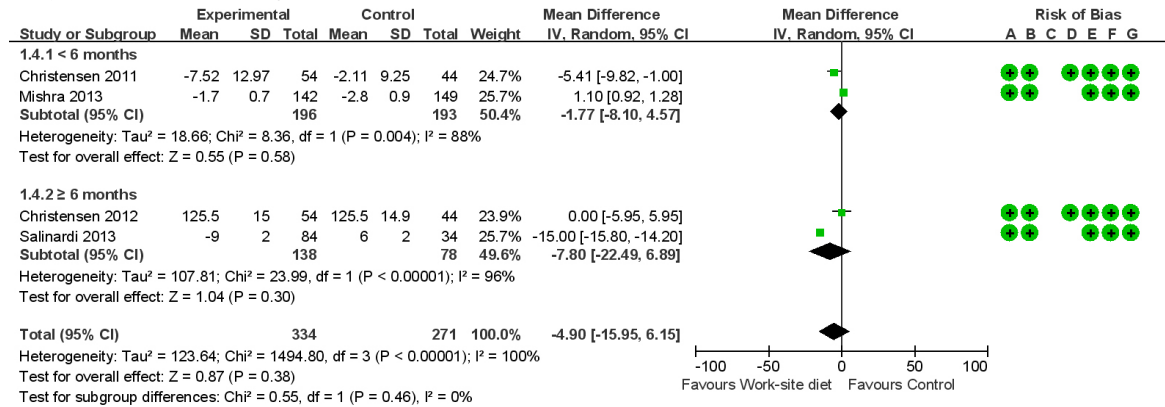


Fig. 3. Comparison of outcomes between experimental and control groups. Risk of bias legend: A = Random sequence generation; B = Allocation concealment; C = Blinding of participants and personnel; D = Blinding of outcome assessment; E = Incomplete outcome data; F = Selective reporting; G = Other bias; ● low risk of bias; ○ unclear risk of bias; ● high risk of bias.

(D) Systolic blood pressure changes



(E) Diastolic blood pressure changes

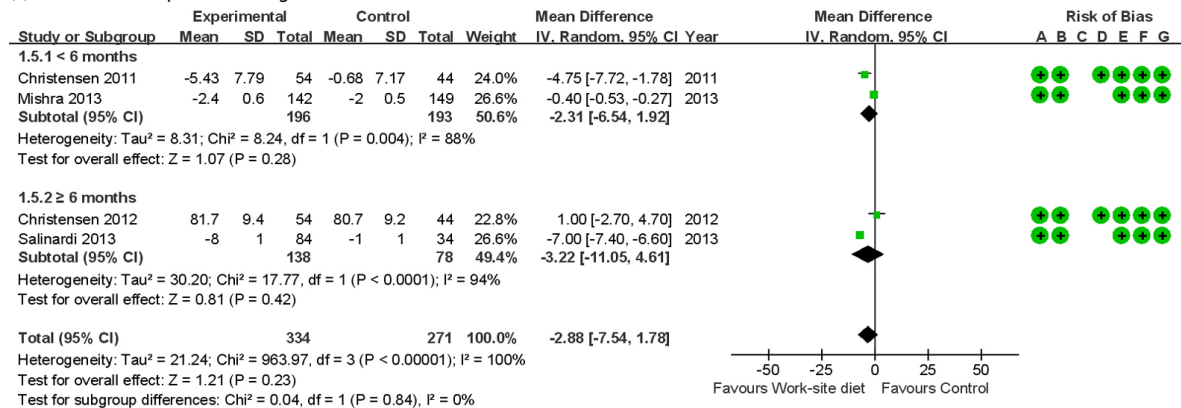


Fig. 3. continued

both the programs that were shorter than 6 months ($\chi^2 = 22.63$, $P < 0.001$) and those that were longer than 6 months ($\chi^2 = 5,365.59$, $P < 0.001$).

Effects of dietary intervention programs on BMI changes

Six studies demonstrated changes in BMI (Fig. 3B). The meta-analysis showed that the BMI decreased with WMD of -1.26 (95% CI: -1.98 to -0.55) kg/m^2 , but it was statistically significant ($Z = 3.47$, $P = 0.0005$).

Additional analysis considering different program durations revealed a statistically significant ($Z = 3.27$, $P = 0.001$) decrease in the BMI with WMD of -0.95 (95% CI: -1.51 to -0.38) kg/m^2 , in programs shorter than 6 months. Programs longer than 6 months also showed a decrease with WMD of -1.68 (95% CI: -4.12 to 0.76) kg/m^2 , but it was not statistically significant ($Z = 1.35$, $P = 0.18$). The heterogeneity among studies was high in both the programs shorter than 6 months ($\chi^2 = 18.03$, $P < 0.001$) and those longer than 6 months ($\chi^2 = 5,173.78$, $P < 0.001$).

Effects of dietary intervention programs on total cholesterol changes

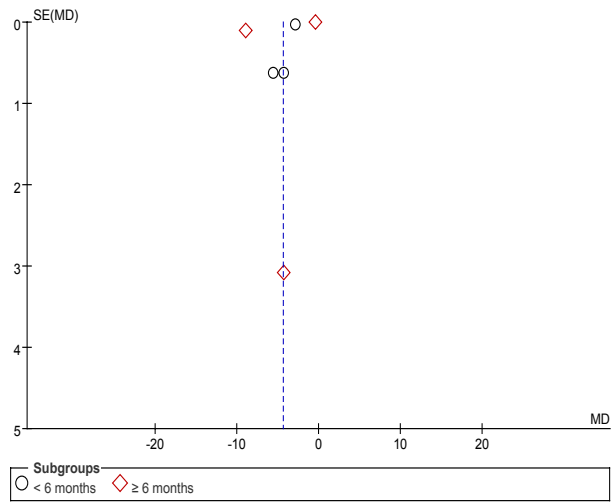
Four studies demonstrated changes in total cholesterol (Fig. 3C). The meta-analysis showed that total cholesterol decreased with WMD of -5.57 (95% CI: -9.07 to -2.07) mg/dL , which was statistically significant ($Z = 3.12$, $P = 0.002$). However, the heterogeneity among studies was very high ($I^2 = 100.0\%$, $\chi^2 =$

$1,409.75$, $P < 0.001$). Additional analysis considering different program durations showed a statistically significant ($Z = 37.19$, $P < 0.001$) decrease in total cholesterol with WMD of -7.99 (95% CI: -8.41 to -7.57) mg/dL , in programs shorter than 6 months. Programs longer than 6 months also showed a significant decrease ($Z = 3.77$, $P = 0.0002$) with WMD of -4.50 (95% CI: -6.85 to -2.16) mg/dL .

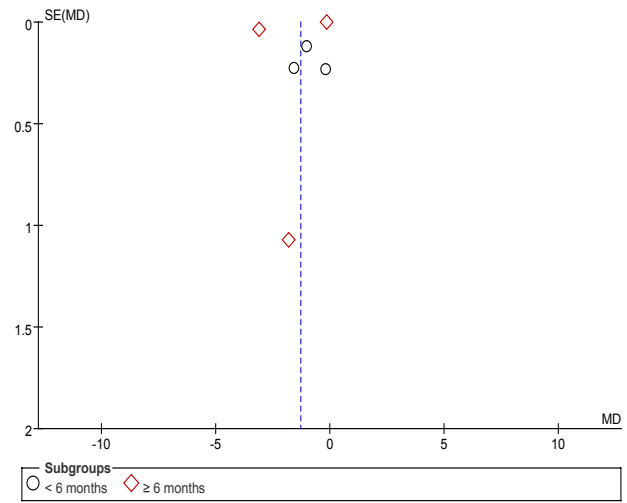
Effects of dietary intervention programs on blood pressure changes

Four studies demonstrated changes in blood pressure. The meta-analysis showed that systolic blood pressure decreased with WMD of -4.90 (95% CI: -15.95 to 6.15) mmHg (Fig. 3D), but it was not statistically significant ($Z = 0.87$, $P = 0.38$). The heterogeneity among studies was very high ($I^2 = 100.0\%$, $\chi^2 = 1,494.80$, $P < 0.001$). Additional analysis considering different program durations demonstrated decrease in systolic blood pressure with WMD of -1.77 (95% CI: -8.10 to 4.57) mmHg , in programs shorter than 6 months, but it was not statistically significant ($Z = 0.55$, $P = 0.58$). Programs longer than 6 months also showed a decrease with WMD of -7.80 (95% CI: -22.49 to 6.89) mmHg , but with no statistical significance ($Z = 1.04$, $P = 0.30$). The heterogeneity among studies was high in both the programs that were shorter than 6 months ($\chi^2 = 8.36$, $P = 0.004$) and those that were longer than 6 months ($\chi^2 = 23.99$, $P < 0.001$).

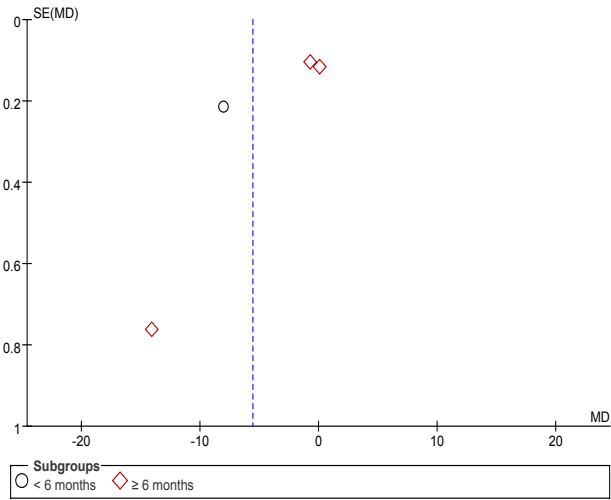
(A) Weight loss



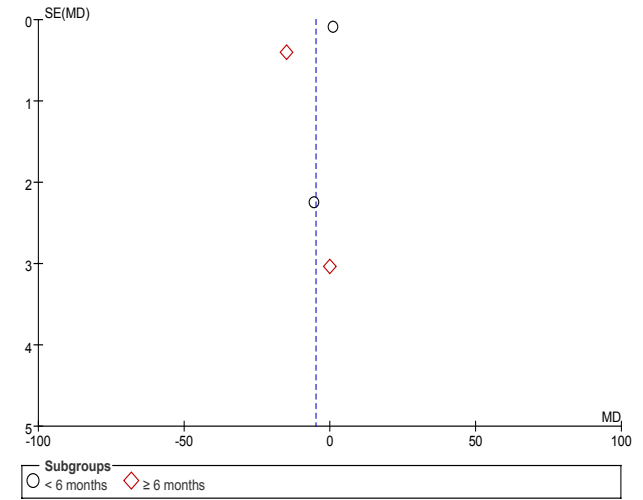
(B) BMI changes



(C) Total cholesterol changes



(D) Systolic blood pressure changes



(E) Diastolic blood pressure changes

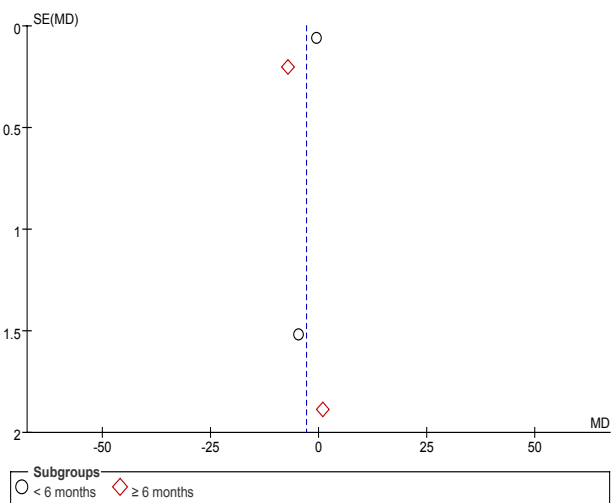


Fig. 4. Funnel plots

Diastolic blood pressure also decreased (Fig. 3E) with WMD of -2.88 (95% CI: -7.54 to 1.78) mmHg with no statistical significance ($Z = 1.21$, $P = 0.23$). Furthermore, the heterogeneity among studies was very high ($I^2 = 100.0\%$, $\chi^2 = 963.97$, $P < 0.001$). Additional analysis considering different program durations demonstrated decrease in diastolic blood pressure with WMD of -2.31 (95% CI: -6.54 to 1.92) mmHg but with no statistical significance ($Z = 1.07$, $P = 0.28$), in programs shorter than 6 months. Programs longer than 6 months also showed a decrease with WMD of -3.22 (95% CI: -11.05 to 4.61) mmHg, but it was not statistically significant ($Z = 0.81$, $P = 0.42$). The heterogeneity among studies was high in both the programs that were shorter than 6 months ($\chi^2 = 8.24$, $P = 0.004$) and those that were longer than 6 months ($\chi^2 = 17.779$, $P < 0.001$).

Publication bias

A slight tendency of publication bias was shown without displaying a distinctive asymmetry (Fig. 4).

DISCUSSION

The present study aimed to analyze the effects of worksite-based dietary intervention programs. The meta analysis of seven RCTs targeting 2,854 employees has provided scientific evidence that proved the effectiveness and significance of short-term worksite-based dietary intervention programs on weight loss and total cholesterol reduction among employees who were overweight or obese.

In May 2004, WHO declared a war against obesity, advocating a "Global strategy on diet, physical activity and health [26]." No single risk factor can cause obesity; rather obesity is caused by a combination of various risk factors including age, race, genetic predisposition, diet, and lifestyle [27]. Nevertheless, people with obesity generally are prone to overeating beyond the recommended amount [28]. Therefore, development of healthy eating habits along with engagement in physical activities has been the main focus of obesity prevention and treatment programs before more drastic pharmacological and surgical options are considered [29].

Worksite has been considered as an optimal setting to apply promotion of health intervention programs because it enables synchronous targeting of the majority of employees and because policies and social norms encouraging healthy behaviors are more easily mandated and enforced. As the strategic significance of worksite emerges, diverse dietary intervention programs have been implemented, and the results have been integrated and published in several systematic reviews [9,12-14]. However, the most common dietary intervention programs included indirect approaches that only offered dietary guidelines and nutrition-related information or education, or provided incentives to motivate people. Therefore, the present study aimed to investigate the effects of more direct and specific dietary intervention programs that either limited the intake of calories and/or certain nutrients such as carbohydrates and fats or recommended balanced intake of energy and relevant nutrients.

Our analysis showed that dietary intervention programs targeting employees, who were overweight or obese, resulted

in effective decrease in weight and total cholesterol to a certain degree; in particular, short-term programs of less than 6 months were more effective than long-term programs. Weight decreased with WMD of -4.37 kg (95% CI: -6.54 to -2.20), which was statistically significant. According to the guideline for management of obesity of SIGN [11], weight loss programs are successful when there is a decrease in weight by 5-10% (approximately 5-10 kg) minimum compared to the initial body weight. Based on this criterion, a weight loss of WMD 4.37 kg in adults, who were overweight or obese, with a BMI 25-35 kg/m² was a successful outcome. Moreover, BMI was also lowered as WMD -1.26 kg/m² (95% CI: -1.98 to -0.55), with statistical significance.

However, it was worthwhile to compare the weight and the BMI before and after 6 months of intervention considering the differences in program duration. In studies that implemented short-term programs less than 6 months (mostly 3 months), weight (WMD -4.12 kg) and BMI (WMD -0.95 kg/m²) showed a statistically significant decrease. In contrast, in studies that implemented long-term programs that lasted more than 6 months, there was a larger decrease in weight (WMD -4.56 kg) and BMI (WMD -1.68 kg/m²) than in the short-term programs, but with no statistical significance.

The difference in study outcomes according to program duration implies that worksite-based dietary interventions targeting overweight or obese employees are clearly more effective in short-term programs of less than 6 months, because participants possibly can better focus their attention and awareness on the diet. In contrast, long-term programs of more than 6 months may lead to greater, yet variable among individuals, weight loss. In fact, previous studies have also shared rather skeptical views on long-term weight loss maintenance [30,31]. However, long-term weight loss maintenance does not seem always impossible. According to the NWCR results, approximately 20% of the participants succeeded in long-term weight loss, and their common strategies were shown to target diet accompanied with physical activity and other behavioral approaches [11,32].

Integration of the findings from the current study and previous studies implies that it is necessary to establish long-term weight loss management strategies to maintain or increase the effect of worksite-based dietary intervention programs on obesity. Furthermore, worksite characteristics should be taken into consideration when formulating intervention strategies. That is, intervention strategies to prevent and treat obesity should be efficiently applied at worksites with the aim to promote healthy habits that participants can consistently implement without conscious effort. As Lally *et al.* mentioned, habit formation tends to be influenced by the surrounding environment [33]; therefore, the generation of a healthy environment at workplace is likely to result in a more positive contribution to maintain the effect of dietary intervention programs for employees with obesity. WHO has also highlighted the fact that obesity is a "social and environmental disease" and that the resolution to the obesity problem requires a strategy to create a healthy environment that encourages healthy choices [34].

Additionally, the results showed that total cholesterol levels decreased with WMD of -5.57 mg/dL, which was statistically

significant. Although the changes in blood pressure were not statistically significant, systolic and diastolic blood pressure decreased with WMD -4.90 mmHg and WMD -2.88 mmHg respectively. When considered in conjunction with weight loss results, it implies that dietary interventions can reduce cardiovascular disease and metabolic risk [11], and affect various parts of human physiology.

The present study has the following limitations. Among the RCTs examined, only two studies used the blinding method, which is required to prevent bias in interpreting research data. The blinding method does not seem feasible because dietary intervention inherently requires that participants themselves choose their food according to the program; the dietary intervention programs in the selected studies incorporated more direct and specific approaches. Another limitation of our study is that heterogeneity among studies and publication bias were observed, although the directionality of the effect in each study was relatively consistent.

Based on the findings of this study, the worksite-based dietary intervention programs for employees with obesity did not appear to have a clear positive effect. Nevertheless, the need for worksite-based dietary interventions with more robust RCTs that are designed to actively prevent and treat obesity should not be ignored. Moreover, many implications can be drawn from the benefit of worksite-based dietary intervention programs that help adult employees to build a healthy eating habit at a worksite where they spend the majority of their time. The effect of worksite-based intervention programs can be regarded as only modest at the individual level; however, at the population level, they are expected to exert a substantial effect on reducing obesity, considering the strategic advantages of worksites and the dispersion effect of positive outcomes through employees' families and social networks. Therefore, we anticipate that our findings will provide a foundation for the design and implementation of more robust worksite-based dietary intervention programs in the future which aim to prevent and treat obesity in employed adults.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interests.

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