International Journal of Obesity (2005) 29, 1168–1174
 0307-0565/05 $30.00
www.nature.com/ijo

REVIEW

Long-term weight loss after diet and exercise: a systematic review

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OBJECTIVE: To assess the effectiveness of dietary interventions and exercise in long-term weight loss in overweight and obese people.
DESIGN: A systematic review with meta-analysis.
SUBJECTS: Overweight and obese adults—18 years old or older with body mass index (calculated as weight divided by the square of height in meters) > 25.
DATA SOURCE: Medline, Cochrane Library and Lilacs databases up to March 2003. Also, published reviews and all relevant studies and their reference lists were reviewed in search for other pertinent publications. No language restrictions were imposed.
STUDY SELECTION: Randomised clinical trials comparing diet and exercise interventions *vs* diet alone. All trials included a follow-up of 1 y after intervention.
DATA EXTRACTION: Two reviewers independently abstracted data and evaluated the studies' quality with criteria adapted from the Jadad Scale and the Delphi list.
DATA SYNTHESIS: The estimate of the intervention's effect size was based on the differences between the comparison groups, and then the overall effect was calculated. A chi-squared test was used to assess statistical heterogeneity.
RESULTS: A total of 33 trials evaluating diet, exercise or diet and exercise were found. Only 6 studies directly comparing diet and exercise *vs* diet alone were included (3 additional studies reporting repeated observations were excluded). The active intervention period ranged between 10 and 52 weeks across studies. Diet associated with exercise produced a 20% greater initial weight loss. (13 kg *vs* 9.9 kg; $z = 1.86$—$p = 0.063$, 95%CI). The combined intervention also resulted in a 20% greater sustained weight loss after 1 y (6.7 kg *vs* 4.5 kg; $z = 1.89$—$p = 0.058$, 95%CI) than diet alone. In both groups, almost half of the initial weight loss was regained after 1 y.
CONCLUSION: Diet associated with exercise results in significant and clinically meaningful initial weight loss. This is partially sustained after 1 y.
International Journal of Obesity (2005) **29,** 1168–1174. doi:10.1038/sj.ijo.0803015; published online 31 May 2005

Keywords: diet; exercise; systematic review; meta-analysis

Introduction

Obesity is a chronic disease that has reached epidemic proportions in both developed and developing countries.[1] In Brazil, prevalence of overweight and obesity increased more than 50% in 30 y. About 40% of adults present some degree of weight excess, and 10% are obese. However, the best strategies to control the epidemic have not been settled yet.

Obesity should be recognised as a disease and treated accordingly, because it increases the risk of several diseases.[2] Weight loss (5–15% of the body weight) in obese individuals reduces the risk factors associated with obesity.[2]

Among the several strategies for obesity treatment, diet and exercise are considered useful for losing weight in moderately obese adults. However, it seems that even losing weight with these approaches, most obese individuals do not maintain the loss for long periods.[3–6] Unfortunately, there are no accepted rules to guide interventions promoting behaviour and lifestyle changes for an effective and permanent weight loss.

The aim of the present study was to carry out a systematic review with meta-analysis of randomised clinical trials assessing the effectiveness of exercise combined with dietary interventions in initial weight loss and its long-term maintenance among overweight and obese people.

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Received 22 September 2004; revised 13 April 2005; accepted 27 April 2005; published online 31 May 2005

Methods

Randomised controlled clinical trials of diet, exercise or both in overweight or obese adult (lowest acceptable age 18 y) patients—body mass index (weight divided by the square of height in meters) >25 as defined by the World Health Organization[1]—were considered for inclusion. The following sources were included in the literature search process: The Cochrane Controlled Trials Register (Cochrane Library), Medline (US National Library of Medicine), and Lilacs (Latin American and Caribbean Literature in Health Sciences), up to March 2003. The search strategy used the following keywords and variations: obesity, overweight, diet, exercise, randomised clinical trial. Also, published reviews and all relevant studies and their reference lists were reviewed in search for other pertinent publications. No language restrictions were imposed. Studies were included if they had a follow-up period after intervention of at least 1 y.

We compared data obtained immediately after intervention period and after 1 y of unsupervised follow-up. Data obtained after periods greater than 1 y were only considered if the 1 y results were not described. Sensitivity analysis was performed to explore differences resulting from the exclusion of such studies.

Diet included any type of caloric restriction, and exercise included any type of exercise in which it was possible to quantify the recommended activity. Studies including pregnant woman or children or the use of any medication were excluded. Diet and exercise interventions could be associated with behavioural therapy. However, studies of behavioural therapy as the only intervention were excluded. No restriction about health status was made. No prespecified weight loss after intervention was required.

Both authors independently considered studies for inclusion. Initially, the reviewers scanned the titles, abstracts and keywords of every article retrieved to determine whether it met the predetermined eligibility criteria. In the presence of any doubt about article inclusion, a final consensus decision was taken after the full text was jointly reviewed.

The study quality was rated using specific quality criteria adapted from the Jadad Scale and the Delphi list.[7,8] Sensitivity analyses were planned to evaluate the possible influence of studies with methodological flaws such as high dropout rates. Of all, 33 trials evaluating diet, exercise or diet and exercise were found. A table with the excluded studies is presented at the end of the article (Appendix A).

For meta-analysis, three values were obtained in each group: the sample size, the mean and its standard deviation. The individual effect size of the intervention was obtained from the magnitude of the differences between groups (reduced weight in the combined intervention group in relation to diet alone controls). The global effect was then calculated with the respective 95% confidence intervals through the inverse variance method. Initially a fixed effects model was used presuming homogeneity among studies.

Heterogeneity between trial results was tested using a standard chi-squared test with a significance level of alpha = 0.1 in view of the low power of such test. Data were analysed using the statistical software Stata 6.0.[9]

Weight loss percentage (and variance) immediately after intervention and after 1 y was obtained through *w*. Where *w*:

(*w1*) early weight loss after intervention = weight loss immediately after intervention (post-intervention)/ baseline weight,

(*w2*) weight loss after 1 y = weight loss after 1 y follow-up/ baseline weight,

(w3) weight maintenance = weight loss after 1 y follow-up/ early weight loss after intervention.

The standard deviation (SD) was calculated through the formulae[10]:

$S^2 = N \times (a/b) \times (1-[a/b])$; and $SD = \sqrt{s^2}$, where S^2—variance.

Results

Descriptive data of the included studies are presented in Table 1. The sample size of the studies varied from 40 to 127 individuals with age ranging from 21 to 65 y. Three studies were performed only with women, one only with men, and two with patients of both genders. The length of the intervention varied from 10 to 52 weeks, and follow-up

Table 1 Descriptive data of studies included in this paper

Reference	*Country*	n	*Sex*	*Age*	*Intervention*	*Dropout rate (%)*	*Length of treatment (weeks)*	*Follow-up (months)*
1. Borg *et al*[11a]	Finland	90	M	35–50	D × D+E	24	32	24
2. Fogelholm *et al*[12]	Finland	82	F	30–45	D × D+E	9.4	40	24
3. Wadden *et al*[13,b]	USA	120	F	30–50	D × D+E	17	48	12
4. Fogelholm *et al*[14]	**Finland**	**82**	**F**	**30–45**	**D × D+E**	**9.4**	**40**	**24**
5. Andersen *et al*[15]	USA	40	F	21–60	D × D+E	17.5	16	12
6. Weinstock *et al*[16,b]	**USA**	**120**	**F**	**30–50**	**D × D+E**	**17**	**48**	**12**
7. Wadden *et al*[17,b]	**USA**	**120**	**F**	**30–50**	**D × D+E**	**17**	**48**	**12**
8. Skender *et al*[18]	USA	127	F & M	25–45	D × E × D+E	19	52	12
9. Wing *et al*[19]	USA	55	F & M	30–65	D × D+E	14.5	10	12

Abbreviations: USA, United States of America; F, female; M, male; D, diet; E, exercise; D+E, diet and exercise; studies excluded from analysis due to data duplicity are in boldface. [a]Two groups with variable intensities of exercise in the original paper were grouped in a single group (using *t*-test) and compared to the diet only group. [b]Three groups with variable intensities of exercise in the original paper were grouped in a single group (using *t*-test) and compared to the diet only group.

from 12 to 24 months. In all but one study, patients were seen once a week during the entire period of intervention, usually in small groups. Among the included studies, some presented duplicated data (12 and 14; 13, 16 and 17). For data analysis, only the last published trials were included. Therefore, six trials were analysed. With regard to the follow-up, the end point chosen for the present analysis was 1 y after the end of the intervention.

The baseline weight average varied from 83.5 to 106 kg (Table 2). The dropout rate was less than 20% in all studies except that from Borg *et al*—24% dropout rate.[11] This same study only presented results at the end of a 23 months follow-up (no data in 1 y after intervention). Therefore, a sensitivity analysis was performed excluding this study.

Most studies only mentioned that that they constituted a randomised controlled trial, only two actually describing the randomising process.[11,12] No study gave information about the blinding process nor made an intention-to-treat analysis.

Individuals in the diet and exercise group had a mean weight loss after intervention approximately 20% greater than individuals in the diet group: -13.0 ± 10.4 kg *vs* -9.9 ± 9.6 kg, $p=0.063$. Heterogeneity was not detected through the chi-square test (Figure 1). The results are not significantly changed if the study N.1[11] is excluded from the analysis (22% greater mean weight loss in the diet and exercise group: -12.9 ± 10.2 *vs* -9.4 ± 7.7, $p=0.066$, -0.46–0.01; 95%CI).

Table 2 Comparison of diet and exercise *vs* diet

	Diet and exercise				*Diet*			
Study (reference)	N	*Baseline weight (kg)*	*Initial weight loss (kg)*	*Weight loss after 1 y (kg)*	N	*Baseline weight (kg)*	*Weight loss intervention (kg)*	*Weight loss after 1 y (kg)*
Study 1[11]	53	106.0±9.9	−13.7±13.6	−5.1±15.6[a]	29	106.0±9.9	−12.1±14.9	−5.3±20.4[a]
Study 2[12]	53	91.3±2.0	−13.8±11.0	−5.6±14.0	29	93.2±1.6	−11.2±10.3	−3.5±9.7
Study 3[13]	91	96.0±13.9	−15.4±9.1	−9.1±9.6	21	96.3±8.8	−14.4±6.2	−6.9±6.3
Study 5[15]	20	83.6±8.6	−8.3±3.8	−6.7±6.7	20	90.5±13.5	−7.9±4.2	−7.8±6.2
Study 8[18]	21	100.1±27.4	−8.9±11.5	−2.2±6.7	15	98.5±25.9	−6.8±7.8	+0.9±7.7
Study 9[19]	27	105.3±5.8	−8.9±6.2	−7.9±6.9	28	100.1±4.9	−6.4±5.2	−3.9±5.2
Total	265	97.4±16.1	−13.0±10.4	−6.7±8.3	142	97.8 ±10.7	−9.9±9.6	−4.5±11.3

[a]The follow-up period was 23 months (unsupervised).

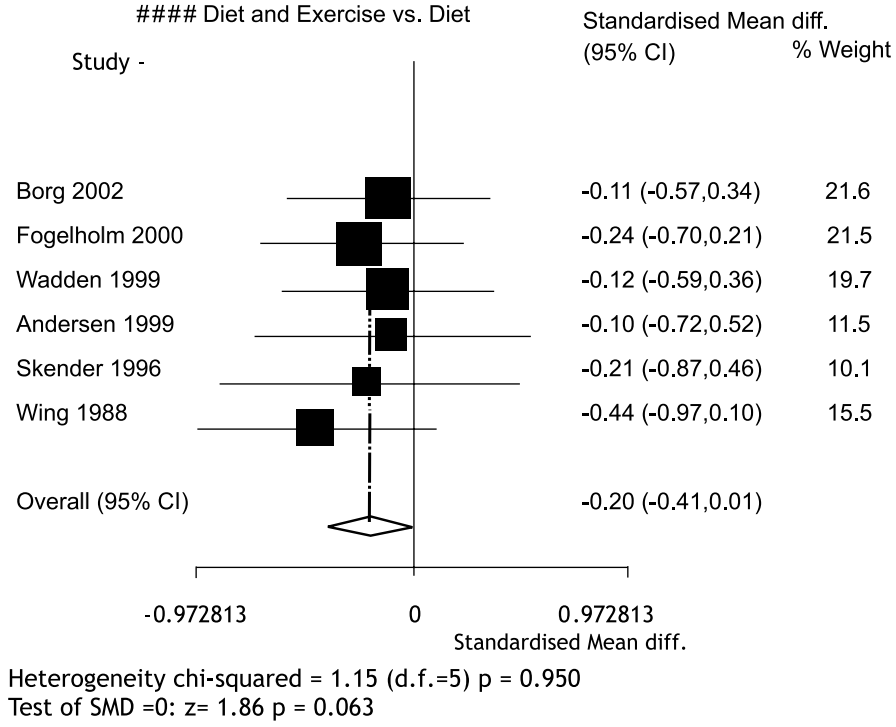

Figure 1 Meta analysis of weight-loss after intervention comparing diet and exercise *vs* diet.

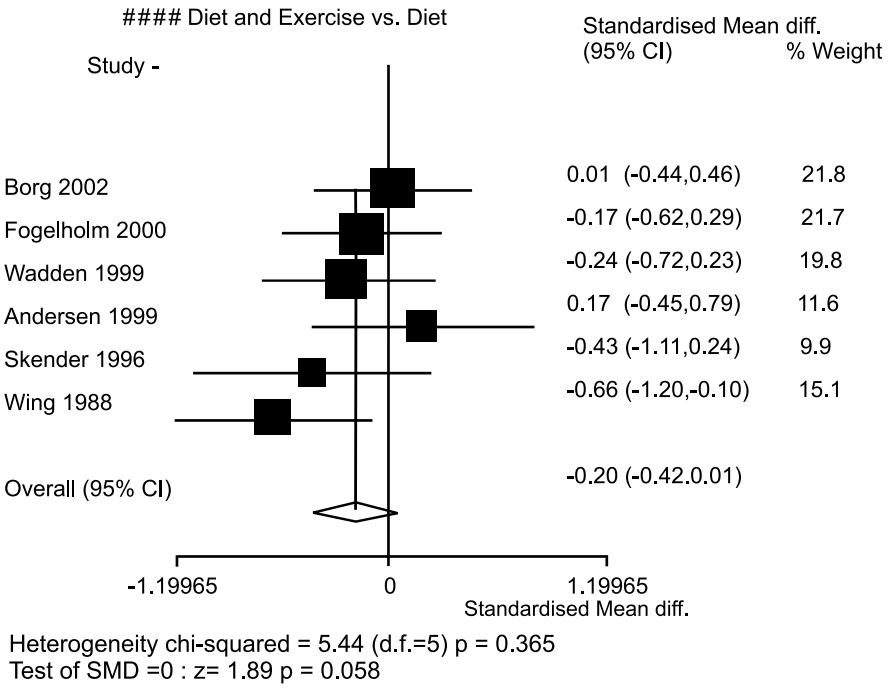

Figure 2 Meta analysis of weight-loss maintenance after 1 y of follow-up comparing diet and exercise *vs* diet.

As to weight loss maintenance after 1 y, diet and exercise also resulted in 20% greater weight loss than diet alone: -6.7 ± 8.3 *vs* -4.5 ± 11.3 kg, $p=0.058$ (Figure 2). The exclusion of the previously mentioned study[11] resulted in slightly different findings of the meta-analysis, however, with more marked differences favouring the diet and exercise group (26% greater weight reduction with diet and exercise group: -7.1 ± 10.3 *vs* -4.4 ± 7.7, $p=0.03$, -0.50 to -0.03; 95% CI).

The percentages of weight loss from baseline weight were: *w1* (immediately after intervention)—13 ± 5.5% for the diet and exercise group and 10 ± 3.6% for the diet group; *w2* (after 1 y)—6.8 ± 4.1 and 4.6 ± 2.5%, respectively. There was a similar weight regain in both groups after 1 y: *w3*—50 ± 8.2 and 50 ± 5.9%. These results are not influenced if study N.1[11] is excluded (data not shown).

Discussion

The present study indicates that programs including both diet and exercise produce greater weight loss than diet alone in obese and overweight individuals soon after the intervention period and after 1 y of follow-up. In both groups, the magnitude of weight reduction immediately after intervention as after 1 y of follow-up is compatible with clinically significant benefits—reduction of cardiovascular risk factors; improvement of glicemic control and hyperinsulinemia in diabetics; decrease of blood pressure, total cholesterol, LDL-cholesterol and triglyceride levels; increase of HDL-cholesterol concentrations.[2,20]

Weight regain in individuals in both interventions approached 50%. Adding exercise to diet did not produce a better long-term maintenance of the lost weight. Fogelholm and Kukkonen-Harjula[21] published a review of physical activity to prevent weight gain analysing both observational studies and randomised clinical trials. Results from observational studies (but not those from the clinical trials also analysed) suggested that exercise leads to successful weight loss maintenance.[21] Also, in contrast to some studies,[22–27] we observed that an initial greater weight loss was very hard to sustain. Our results suggest that individuals changed their lifestyle, but just for a short period, since they partially returned to their previous patterns. This study only evaluated weight loss, which did not allow us to determine the reasons for weight regain. Additional outcomes would be necessary to evaluate possible associations—behavioural and physiologic factors, among others. It would be also important to explore differences among individuals that regained weight and those who maintained the lost weight.

The great difficulty and limitation of weight loss studies is that they only report the mean group weight changes and not the frequency of expected responses to the interventions, *ie*, how many people actually lost weight. Means are not appropriate to evaluate how many people attained a clinically significant weight loss.

A number of systematic reviews on weight loss and maintenance related to diet and physical activity have been published. McTigue *et al*[28] reported that counselling on diet or physical exercise and behavioural interventions resulted in small to moderate degrees of sustained weight loss (3–5 kg)

over at least 1 y. However, the results of the studies could not be grouped, and those reporting some success in weight maintenance were commented on individually. Miller *et al*[29] reported an initial weight loss of 11% of the baseline weight, and of 7–9% after 1 y of follow-up. Anderson *et al*[6] reported maintenance of 11% reduction in initial weight after 1 y of follow-up. All these systematic reviews included only cohort studies. The present study, on the other hand, included only controlled clinical trials, which evaluate more accurately the true intervention effect on the long-term weight loss.[30]

Other systematic reviews on obesity management are worth mentioning. In general, their results support our own findings. In the review from Fogelholm and Kukkonen-Harjula,[21] most clinical trials did not find that exercise training improve weight maintenance. Glennny *et al*[31] in another review evaluating many aspects of obesity treatment and prevention, reported that most trials included demonstrate weight regain either during or after the intervention period.

A number of limitations of the present analysis should be acknowledged. Most studies were of poor quality: few described clearly the randomising process and none included intention-to-treat analyses. In addition, subgroup analyses by sex, age and initial weight would be important to explore effect size differences. The funnel plot to investigate the existence of publication bias could not be evaluated. With a limited number of studies included, this analysis has limited power to detect bias and the results can be distorted.[32]

In conclusion, the present study confirms the important role of diet and exercise in short and long-term weight loss. Diet associated with exercise can provide greater initial weight-loss than diet alone. Most importantly, we have shown that after 1 y the combined approach is also associated with greater weight loss than diet alone, in a range compatible with clinically relevant benefits. Both types of studied interventions are, however, associated with partial long-term weight regain (50% in 1 y). Programs to treat obese and overweight individuals should explore the best strategies to promote prolonged changes in lifestyle leading to caloric adequacy and increase in physical activity.

Future researchers should identify program patterns that are more effective in the long-term. Although dropouts cannot always be controlled, all effort should be made to verify their reasons. This would allow a better knowledge of the factors that affect adherence to therapeutic programs. The results should also include outcomes such as frequency of pre-established responses to interventions. In order to attain higher levels of scientific evidence, future randomised clinical trials should also describe the randomisation and blinding processes and include intention-to-treat analyses.

Acknowledgements

The authors thank: Rosely Sichieri, MD, PhD, Instituto de Medicina Social—Universidade do Estado do Rio de Janeiro; and Charles André, MD, PhD, Universidade Federal do Rio de Janeiro for valuable suggestions.

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Appendix A

Table A1 Table of excluded trials

Study reference	*Baseline BMI (kg/m^2) or % of ideal weight*	*Age(Y)*	*Intervention*	*Duration of intervention (Weeks)*	*Follow-up (Months)*	*Reason for exclusion*
King *et al*[33]	120–160%	30–59	D × E × C	52	12	There is no diet+exercise group
Jeffery *et al*[34]	14–32 kg over ideal weight	25–45	D+E × C	52	18	There is no diet only group
Pavlou *et al*[35]	122%	26–52	D × D+E	8	18	Information only available in graph, with values not described
Perri *et al*[36]	160%	22–60	BT+E+M × BT+E × BT+M × BT	20	18	There is no diet intervention, only behavioral therapy (BT) in groups; the M group was periodically contacted during follow-up.
Sikand *et al*[37]	170–200%	21–60	D × D+E	20	24	The follow-up weight is self-reported; poor methodological quality
Tuomilehto *et al*[38]	26.5–35.9	40–65	D+E × C	52	12	There is no diet only group
Uusitupa *et al*[39]	26.5–35.9	40–65	D+E × C	52	12	There is no diet only group
van Dale *et al*[40]	32.3 (mean)	34 (mean)	D × D+E	12–14	18–42	Not a randomized clinical trial: subjects entered in three different diet-exercise studies

BT, behavioral therapy; C, control; D, diet; E, exercise; M, multicomponent maintenance program. Other studies exclusively comparing two different interventions of diet were also excluded.[41–57]