Long-term weight-loss maintenance: a meta-analysis of US studies[1–3]

James W Anderson, Elizabeth C Konz, Robert C Frederich, and Constance L Wood

ABSTRACT

Background: Current perception is that participants of a structured weight-loss program regain all of their weight loss within 5 y.

Objective: The objective was to examine the long-term weight-loss maintenance of individuals completing a structured weight-loss program.

Design: Studies were required to *1*) have been conducted in the United States, *2*) have included participants in a structured weight-loss program, *3*) have provided follow-up data with variance estimates for ≥2 y. Primary outcome variables were weight-loss maintenance in kilograms, weight-loss maintenance as a percentage of initial weight loss, and weight loss as a percentage of initial body weight (reduced weight).

Results: Twenty-nine studies met the inclusion criteria. Successful very-low-energy diets (VLEDs) were associated with significantly greater weight-loss maintenance than were successful hypoenergetic balanced diets (HBDs) at all years of follow-up. The percentage of individuals at 4 or 5 y of follow-up for VLEDs and HBDs were 55.4% and 79.7%, respectively. The results for VLEDs and HBDs, respectively, were as follows: weight-loss maintenance, 7.1 kg (95% CI: 6.1, 8.1 kg) and 2.0 (1.5, 2.5) kg; percentage weight-loss maintenance, 29% (25%, 33%) and 17% (13%, 22%); and reduced weight, 6.6% (5.7%, 7.5%) and 2.1% (1.6%, 2.7%). Weight-loss maintenance did not differ significantly between women and men. Six studies reported that groups who exercised more had significantly greater weight-loss maintenance than did those who exercised less.

Conclusions: Five years after completing structured weight-loss programs, the average individual maintained a weight loss of >3 kg and a reduced weight of >3% of initial body weight. After VLEDs or weight loss of ≥20 kg, individuals maintained significantly more weight loss than after HBDs or weight losses of <10 kg. *Am J Clin Nutr* 2001;74:579–84.

KEY WORDS Weight maintenance, weight loss, meta-analysis, very-low-energy diet, hypoenergetic balanced diet

INTRODUCTION

Obesity is a chronic disease that is a major health problem in the United States and is emerging as a health problem in many developed and developing countries (1). Current treatment programs for obese individuals are not very effective over the long term, leading to the common wisdom that persons who successfully lose weight will regain it all within 5 y (2, 3).

The combination of very-low-energy diets (VLEDs) with behavior modification represents an important advance in enabling obese individuals to initially lose substantial amounts of weight, typically 20–25 kg (4). However, the National Task Force on the Prevention and Treatment of Obesity (5) indicated that long-term maintenance of weight loss after VLEDs is no better than after other forms of obesity treatment. The present meta-analysis critically examines that contention by examining available US reports of weight-loss maintenance from 2 to 5 y after successful weight loss in structured weight-loss programs. Furthermore, because the recommended rate and amount of weight loss is a focus of debate (6), we examined long-term weight-loss maintenance and weight reduction at 5 y after either VLEDs or hypoenergetic balanced diets (HBDs).

MATERIALS AND METHODS

Study identification

In evaluating the literature for studies of weight-loss maintenance, we defined 3 initial inclusion criteria. First, only US studies were evaluated because of differences in weight-management practices and the availability of medical care in different countries. Second, subjects must have participated in a structured weight-loss program instead of in self-help activities. Third, follow-up weights with variance estimates must have been available for ≥2 y. We performed a thorough literature search by using MEDLINE (National Library of Medicine, Bethesda, MD) for the period of 1970–1999 to identify candidate studies and also used the "ancestry approach" (7) by consulting reference lists from

[1] From the VA Medical Center, Graduate Center for Nutritional Sciences, University of Kentucky Health Management Resources Weight Management Program, Lexington, and the Departments of Internal Medicine and Biostatistics, University of Kentucky, Lexington.

[2] Supported in part by Health Management Resources, the HCF Nutrition Research Foundation, and Veterans Administration Career Development Award 596522803585003.

[3] Address reprint requests to JW Anderson, Medical Service, 111C, 2250 Leestown Road, Lexington, KY 40511. E-mail: jwandersmd@aol.com.

Received July 24, 2000.

Accepted for publication January 25, 2001.

single studies and pertinent literature reviews. We reviewed data from primary scientific reports and in review articles. Thirty-one separate published reports (4, 8–37) met the initial criteria. We excluded 2 reports (19, 22) because they did not provide specific weight-loss information at follow-up times. A study conducted by Wing et al (38) was also excluded from the analysis because the study included only children of persons with type 2 diabetes, a group shown to be atypical of the general population (39).

The primary outcome measures were weight-loss maintenance in kilograms, weight-loss maintenance as a percentage of initial weight loss (percentage weight-loss maintenance), and weight loss as percentage of initial body weight (reduced weight). Follow-up values were assessed at 1, 2, 3, 4, and 5 y. We analyzed results as reported and did not adjust for self-reported weights. Most investigators used VLEDs of <800 kcal/d (3347 kJ/d) or HBDs during the weight-loss phase. One group (34, 35) used VLEDs and HBDs for comparison; these groups were considered to be mixed and were not analyzed in either diet group but were included in other comparisons.

Meta-analysis

Three studies included some randomization in design but most studies were observational. Long-term randomized controlled studies of weight loss and weight maintenance are not available. Meta-analysis of observational studies is appropriate in the absence of randomized controlled studies (40–43), and observational studies were included in the analysis to maximize the statistical power. In our analysis, estimates of diet, sex, and follow-up at each year were conducted by using the fixed effects model assumptions (44), homogeneity of results across studies was evaluated (45), and 95% CIs for these effects were calculated. All analyses were conducted by using SAS-PC (version 8.00; SAS Institute, Inc, Cary, NC) with the use of formulas from Shadish and Haddock (46) and by adapting code provided by Wang and Bushman (47) to calculate the fixed effects model and compute homogeneity as described previously (46–48).

For each study, summary results of all reported values and additional relevant study attributes were recorded, coded, and tabulated for analysis. The primary effect estimate was calculated as follows:

$$\text{Weight-loss maintenance (kg)} = \text{initial body weight} - \text{body weight at follow-up} \quad (1)$$

Other outcome variables were calculated as follows:

$$\text{Percentage weight-loss maintenance (\%)} = (\text{weight-loss maintenance/average initial weight loss}) \times 100 \quad (2)$$

$$\text{Reduced weight (\%)} = (\text{weight-loss maintenance/average initial body weight}) \times 100 \quad (3)$$

The variance estimates for these 2 outcome variables, respectively, were calculated as follows: variance(weight-loss maintenance)/(average initial weight loss)^2 and variance(weight-loss maintenance)/(average initial body weight)^2.

RESULTS

The demographic data from the 29 studies analyzed is shown in **Table 1**. Sample sizes ranged from 6 to 508 subjects. Except for 3 studies in women (20, 33, 34) and 1 study in men (23), most studies included both women and men, with a predominance of women. The subjects' mean ages ranged from 31 to 59 y (median: 45 y). Thirteen studies used VLEDs and 14 studies used HBDs; Wadden et al (34, 35) used both VLEDs and HBDs. The length of treatment in the weight-loss phase ranged from 8 to 30 wk (median: 19 wk); the median length of treatment for the VLEDs was 22 wk and that for the HBDs was 12 wk ($P < 0.001$). Average initial body weights for women ranged from 74 to 121 kg and those for men ranged from 100 to 148 kg. Average initial weight losses ranged from 3.5 to 37.9 kg for women and from 6.2 to 44.2 kg for men. In 9 of the 29 reports, investigators provided a structured maintenance program after completion of the weight-loss phase. The number of subjects available for follow-up, as a percentage of subjects completing the weight-loss program, ranged from 50% to 100% (median: 82%). Self-reported weights in these studies ranged from 0% to 100%.

The pattern of weight-loss maintenance in all groups, in the VLED group, and in the HBD group is illustrated in **Figure 1**. There was significant heterogeneity ($P < 0.0001$) when all groups (women and men and VLEDs and HBDs) were combined. This heterogeneity appeared related to the combination of sex and diet because subgroup analysis showed homogeneity for women and for VLEDs at most years of follow-up. When all studies were included, follow-up data were available for 13, 20, 10, 8, and 8 studies at 1, 2, 3, 4, and 5 y, respectively. Individuals maintained 67% (95% CI: 65%, 69%) of their initial weight loss at 1 y, 44% (95% CI: 42%, 46%) at 2 y, 32% (95% CI: 29%, 32%) at 3 y, 28% (95% CI: 25%, 30%) at 4 y, and 21% (95% CI: 18%, 25%) at 5 y.

Weight-loss maintenance, percentage weight-loss maintenance, and reduced weight did not differ significantly between women and men at years 1–5 (data not shown). ANOVA testing indicated no significant differences between men and women when diets were considered. Also, the magnitude of the significant differences between the VLEDs and the HBDs were similar for women and men. VLED participants lost significantly more weight initially and maintained significantly greater weight losses than did HBD participants. As illustrated in Figure 1, VLED participants maintained significantly more weight loss in kilograms than did HBD participants. Percentage weight-loss maintenance was higher after VLEDs than after HBDs, but the differences were significant only at 1 y. Reduced weight was significantly greater at all years after VLEDs than after HBDs. Reduced weight values were as follows for the VLEDs and HBDs, respectively: 1 y, 16.1% (95% CI: 15.4%, 16.8%) and 7.2% (95% CI: 6.6%, 7.9%); 2 y, 9.7% (95% CI: 9.0%, 10.3%) and 4.2% (95% CI: 3.8%, 4.6%); 3 y, 7.8% (95% CI: 6.9%, 8.6%) and 3.5% (95% CI: 2.8%, 4.3%); 4 y, 7.0% (95% CI: 6.2%, 7.8%) and 2.8% (95% CI: 2.1%, 3.4%); and 5 y, 6.2% (95% CI: 5.0%, 7.4%) and 2.0% (95% CI: 1.4%, 2.6%).

After the HBDs, percentage weight-loss maintenance and reduced weight at 5 y were significantly lower than the values at 3 y, suggesting continued weight gain in this group between years 3 and 5 of follow-up. In contrast, after the VLEDs, weight-loss maintenance, percentage weight-loss maintenance, and reduced weight at 5 y did not differ significantly from the values at 3 y, suggesting that this group did not gain significant amounts of weight between 3 and 5 y of follow-up.

The weight-loss maintenance, percentage weight-loss maintenance, and reduced weight values for all groups are presented in **Table 2**. For most comparisons, differences between years 4 and 5

TABLE 1
Demographic data for all studies[1]

Reference	*n*	Sex	Age	Diet	Length of treatment	Initial weight	Weight loss	Follow-up years	Available for follow-up[2]	Self-reported weight[3]
			y		*wk*	*kg*	*kg*		*%*	*%*
Anderson et al (8)	71	F	43	VLED	17	94	17.9	1, 2, and 4	58	100
	29	M	43	VLED	12	116	18.2	1, 2, and 4	58	100
Anderson et al (4)	72	F	41	VLED	22	106.8	31.9	1 and 2	73	0
	28	M	41	VLED	21	125.1	36	1 and 2	73	0
Anderson et al (9)	55	F	42	VLED	28	120.7	32.4	1 and 2	58	80
	25	M	44	VLED	23	148	41.6	1 and 2	58	80
Anderson et al (10)	112	F and M	46	VLED	22	108	29.1	1, 2, 4, and 5	100	30
	72	F	46	VLED	24	96.4	26.5	3	100	30
	40	M	43	VLED	21	128.8	35.6	3	100	30
Dubbert and Wilson (11)	62	F and M	NA	HBD	19	91.1	7.8	1 and 2	96	100
Eubank et al (12)	45	F and M	50	VLED	23	100	28	2	82	4.4
Fitzwater et al (13)	213	F and M	40	HBD	30	103.4	7.3	2	69	60
Flynn and Walsh (14)	189	F	43	VLED	17	102.8	37.9	2	83	100[4]
	66	M	46	VLED	18	123.9	39.1	2	83	100[4]
Graham et al (15)	62	F and M	46	HBD	8	97.7	4.5	5	97	0
Grodstein et al (16)	325	F and M	NA	VLED	22	105.9	22	3	59	100
Hall (17)	10	F and M	NA	HBD	10	83.3	6.1	2	90	0
Hartman et al (18)	73	F	42	VLED	22	99.5	24.7	2	74	43[4]
	29	M	46	VLED	22	116.5	33.5	2	74	43[4]
Hensrud et al (20)	24	F	59	HBD	15	73.5	12.5	1, 2, 3, and 4	92	12
Holden et al (21)	80	F	47	VLED	23	108	25.2	3	100	100
	38	M	46	VLED	27	140.1	44.2	3	100	100
Jeffery et al (23)	89	M	53	HBD	15	100.2	13.5	1 and 2	93	0
Jordon and Canavan (24)	437	F and M	47	HBD	20	97.9	8.5	3 and 5	85	100
Kirschenbaum et al (25)	65	F and M	38	HBD	12	86.8	6.1	2	90.3	0
Kramer et al (26)	83	F and M	53	HBD	15	100.5	13	5	93	7.2[4]
	38	F	48	HBD	15	83.1	8.6	1, 2, 3, and 4	76	7.2[4]
	114	M	51	HBD	15	101.1	13	1, 2, 3, and 4	76	7.2[4]
Lavery and Loewry (27)	386	F	45	HBD	8	78.7	3.5	2	98	100
	123	M	45	HBD	8	101.3	6.2	2	98	100
Murphy et al (28)	34	F and M	NA	HBD	10	87.5	7.4	1, 2, and 4	77	61.8
Nunn et al (29)	44	F	51	VLED	22	98.9	23.2	1 and 2	82	18[4]
	16	M	48	VLED	22	119.1	27.7	1 and 2	98	18[4]
Pavlou et al (30)	49	F and M	38	HBD	12	100.1	13.3	3	63	4.4
Stunkard and Penick (31)	32	F and M	40	HBD	12	97	8.2	5	84	63
Stalonas et al (32)	30	F	31	HBD	10	79.4	4.9	5	82	0
	6	M	31	HBD	10	101.6	6.3	5	82	0
Sikand et al (33)	30	F	39	VLED	17	106.1	19.8	2	50	100
Wadden et al (34)	50	F and M	44	Mixed	23	108.8	16.1	1 and 3	90	6.7
Wadden et al (35)	76	F	42	Mixed	23	106	14.6	1 and 5	62	47[4]
Wadden and Frey (36)	508	F	44	VLED	26	104.9	23.7	2, 3, 4, and 5	54	100
	113	M	47	VLED	26	134.1	34.3	2, 3, 4, and 5	54	100
Walsh and Flynn (37)	189	F	45	VLED	18	100.7	19.7	4	52.4	100[4]
	66	M	47	VLED	19	123.3	27.2	4	66.7	100[4]

[1] VLED, very-low-energy diet; HBD, hypoenergetic balanced diet.
[2] Percentage of initial subjects who completed the study at the final follow-up.
[3] Percentage self-reported weight loss at last follow-up.
[4] Adjusted by original authors for self-reported weight loss by adding 1.5–2.3 kg to the subjects' reported weight.

were not significant; analyzing data for the last available year, either year 4 or 5, also decreased heterogeneity.

Men were significantly heavier ($\bar{x}$: 115 kg; 95% CI: 110, 120 kg) than were women ($\bar{x}$: 95 kg; 95% CI: 86, 104 kg) but weight losses did not differ significantly and patterns of weight regain were similar between the sexes. We noted no significant differences in weight-loss maintenance, percentage weight-loss maintenance, or reduced weight between women and men. Follow-up weights were available at 4–5 y (average: 4.4 y) for women from 6 studies and for men from 5 studies. At these 4–5-y follow-up points, the following comparisons were noted: weight-loss maintenance was 4.66 kg for women and 4.70 kg for men; percentage weight-loss maintenance was 23.60% for women and 30.50% for men; and reduced weight was 4.67% for women and 4.48% for men.

Four VLED-studies that included 578 participants provided follow-up data for 4 or 5 y. Eight HBD studies that included 448 participants provided follow-up data for 4 or 5 y. At an

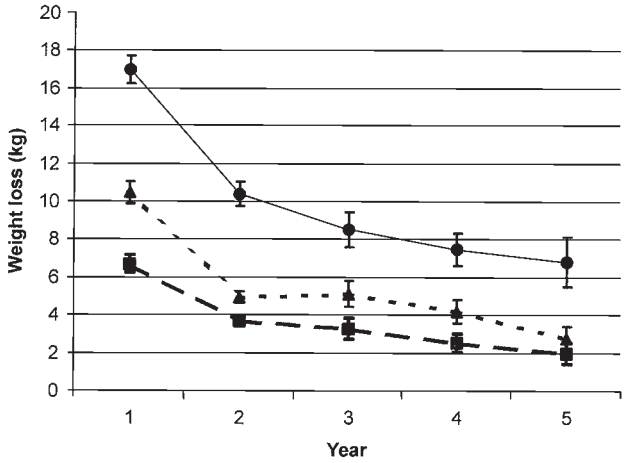

FIGURE 1. Weight reduction maintained over time. Values are weighted means (±95% CIs) for all subjects (▲), subjects consuming very-low-energy diets (●), and subjects consuming hypoenergetic balanced diets (■). In the very-low-energy and hypoenergetic balanced diet groups, respectively, n = 298 and 152 at 1 y, 1307 and 650 at 2 y, 778 and 152 at 3 y, 688 and 152 at 4 y, and 337 and 36 at 5 y.

average of 4.5 y of follow-up, weight-loss maintenance, percentage weight-loss maintenance, and reduced weight were significantly lower with HBDs than VLEDs. These comparisons for VLEDs and HBDs, respectively, were as follows: weight-loss maintenance, 7.05 and 1.99 kg; percentage weight-loss maintenance, 29.40% and 17.80%; and reduced weight, 6.59% and 2.11%.

All 4 VLED studies reported weight losses of ≥20 kg and 5 HBD studies reported weight losses of <10 kg. Comparisons of the groups with weight losses of ≥20 kg with those with weight losses <10 kg were almost identical to the results of the comparisons of the VLEDs and HBDs. Duration of the initial structured weight-loss program was not significantly correlated with weight-loss maintenance, percentage weight-loss maintenance, or reduced weight. We could not match groups with maintenance programs to make meaningful comparisons.

Six studies (12, 14, 18, 21, 30, 33) provided information related to the effects of exercise on weight-loss maintenance (Table 2). Initial body weights and weight losses did not differ significantly between lower and higher exercise groups. Follow-up weights were provided for patients for periods between 2 and 3.3 y (average: 2.7 y). The groups with higher amounts of exercise were significantly more successful in maintaining their weight loss than were the groups with lower amounts of physical activity. The values for lower exercise and higher exercise groups, respectively, were as follows: weight-loss maintenance, 7.47 and 14.99 kg; percentage weight-loss maintenance, 27.20% and 53.80%; and reduced weight, 6.66% and 12.49%.

According to the weighted regression model, 3 variables—follow-up at each year, diet, and sex—explained 61.6% of the variability of weight maintained. Further results of the multiple regression analysis showed that 61.7% of the variability in reduced weight and 50.0% of the variability in weight-loss maintained was explained by these same 3 variables.

DISCUSSION

This analysis of 5-y weight-loss maintenance indicates, on average, that obese individuals maintained weight losses of ≈3.0 kg, representing a reduced weight of ≈3.2% below initial body weight. These individuals were successfully maintaining a weight loss averaging ≈23.4% of their initial weight loss at 5 y. These average values are higher than those reported in earlier studies (24, 32, 35) and indicate that most individuals who participate in structured weight-loss programs in the United States of the type reported in the literature do not regain all of the weight lost at 5 y of follow-up. McGuire et al (49) reached similar conclusions from a random, cross-sectional telephone survey of US adults.

The weight-loss maintenance and reduced weight results reported here are limited by the observational design of the studies included. The interpretation of these results should take into consideration that the true effect of a weight-loss intervention could be best assessed in a long-term, randomized controlled clinical trial. In particular, the greatest limitation of these studies is the absence of an accurate estimation of weight changes in an identical untreated population. Thus, weight changes can only be compared with baseline body weights. The studies analyzed did not provide information on dieting practices between the weight-loss phase and the follow-up periods. Some of the subjects assessed did not complete their structured weight-loss program; thus, these results may not accurately reflect long-term maintenance of weight loss for compliant subjects who completed their structured weight-loss program.

TABLE 2
Weight maintenance of all subjects and of selected subgroups[1]

Group	Years of follow-up	No. of studies	No. of subjects	Inital weight[2]	Weight loss[2]	Weight-loss maintenance[3]	Percentage weight-loss maintenance[3]	Reduced weight[3]
	y			*kg*	*kg*	*kg*	*%*	*%*
All	4.5	13	1081	98	14.00	3.00 (2.54, 3.45)	23.40 (20.4, 26.4)	3.15 (2.69, 3.62)
Men	4.4	5	247	115	18.30	4.70 (2.86, 6.54)	30.50 (21.5, 39.4)	4.48 (2.89, 6.06)
Women	4.4	6	534	95	16.60	4.66 (3.52, 5.80)	23.60 (18.4, 28.8)	4.67 (2.55, 5.79)
VLED	4.5	4	578	106	24.10	7.05 (6.04, 8.06)	29.40 (25.2, 33.6)	6.59 (5.65, 7.54)
HBD	4.5	8	448	93	8.80	1.99 (1.47, 2.51)	17.80 (13.4, 22.2)	2.11 (1.56, 2.65)
Lower exercise	2.7	6	272	110	22.00	7.47 (6.29, 8.66)	27.20 (22.8, 31.6)	6.66 (5.61, 7.71)
Higher exercise	2.7	6	220	110	20.90	14.99 (13.48, 16.49)	53.80 (48.4, 59.2)	12.49 (11.24, 13.74)

[1] Percentage weight-loss maintenance is as a percentage of initial weight loss and reduced weight is as a percentage of initial body weight. VLED, very-low-energy diet; HBD, hypoenergetic balanced diet.

[2] $\bar{x}$.

[3] $\bar{x}$; 95% CI in parentheses.

These mean data can be compared with reports from Wadden and Frey (36) and our group (10) on the percentage of patients who successfully completed similar VLED programs. At 5 y, the success rates for maintaining a 5% reduction in body weight were as follows: 57.9% for men (36), 47.8% for women (36), and 40.2% for men and women (10). At 5 y, the success rates for maintaining a 10% reduction in body weight were as follows: 28.1% for men (36) and 31.3% for women (36). We (10) reported that 25% of our patients were maintaining a 10% reduction in body weight at 7 y.

After VLEDs or after weight losses of ≥20 kg, individuals maintained a significantly greater weight loss at 5 y than after HBDs or weight losses of ≤10 kg. Our analysis suggest that individuals are more likely to sustain long-term weight losses of ≥5% of initial body weight if they participate in VLEDs or lose ≥20 kg initially. This is not consistent with the common recommendation that individuals lose weight slowly and set initial weight-loss goals of ≈5% of their body weight (3, 6).

These observations do not consider the possibility that individuals who participated in these weight-loss programs may have gained weight over the next 5 y if they had not participated. Previously, we (10) cited literature to suggest that untreated women are likely to gain 1 kg (50) to 3 kg (51) to 6 kg (52) over a 5-y period. Recently, Rothacker (53) added to this information base. Over a 5-y period, matched control subjects for a meal-replacement study gained ≈6.5 kg. Thus, participants in these structured programs maintaining a weight loss of 3 kg may actually be 4–10 kg below the weight they would have been if they had not participated in the structured program 5 y previously. Persons who participated in a VLED program or lost >20 kg may be maintaining a weight loss of 8–14 kg below their expected weight at 5 y of follow-up.

Our study confirmed the important role of exercise in weight-loss maintenance. Although persuasive prospective clinical trials have not been done to evaluate the long-term benefits of regular exercise for weight-loss maintenance, the 6 studies analyzed in this report and other extensive evidence (16, 54–56) emphasize the importance of exercise in long-term weight maintenance.

Predictors of long-term weight-loss maintenance have not been clearly identified because, in large part, there is a paucity of long-term data to test hypotheses. Our observations provide data for further hypothesis development. Exercise appears to be positively related to successful weight-loss maintenance. Use of VLEDs or weight loss of ≥20 kg also was strongly related to long-term successful weight-loss maintenance. In this analysis we observed no significant difference in weight-loss maintenance or weight reduction between women and men. Although we detected no significant effects of the duration of the initial weight-loss program, the power of this meta-analysis was not adequate to detect differences between groups. The report from the National Weight Control Registry (57) indicates that selected individuals are successfully maintaining substantial amounts of weight loss over the long-term. Some of the characteristics of these successful weight-loss maintainers were a low intake of fat (24% of energy) and a high level of physical activity (equivalent to walking ≈28 miles/wk). The results of our analysis agree with these results but also suggest that successful weight loss of >20 kg may be an important contributor to weight maintenance. Research on the use of meal replacements (53, 58) in maintaining weight loss and our clinical experience (L Gotthelf, LTP Stifler, and JW Anderson, unpublished observations, 2001) with meal replacements suggests that this may be another important weight-loss maintenance strategy.

In conclusion, this meta-analysis of 29 reports of long-term weight-loss maintenance indicated that weight-loss maintenance 4 or 5 y after a structured weight-loss program averages 3.0 kg or 23% of initial weight loss, representing a sustained reduction in body weight of 3.2%. Individuals who participated in a VLED program or lost ≥20 kg had a weight-loss maintenance at 4 or 5 y of 7 kg or 29% of initial weight loss, representing a sustained reduction in body weight of 6.6%. Although success in weight-loss maintenance has improved over the past decade, much more research is required to enable most individuals to sustain the lifestyle changes in physical activity and food choices necessary for successful weight maintenance.

REFERENCES

1. Bjorntorp P. Obesity. Lancet 1997;350:423–6.
2. Anderson T, Backer OG, Stockholm KH, Quaade F. Randomized trial of diet and gastroplasty with diet alone in morbid obesity. N Engl J Med 1984;310:352–6.
3. Brownell KD, Jeffrey RW. Improving long-term weight loss: pushing the limits of treatment. Behav Ther 1987;18:353–74.
4. Anderson JW, Hamilton CC, Brinkman-Kaplan VL. Benefits and risks of an intensive very-low-calorie diet program for severe obesity. Am J Gastroenterol 1992;87:6–15.
5. The National Task Force on Prevention and Treatment of Obesity. Towards prevention of obesity: research directions. Obes Res 1994; 2:571–84.
6. Pi-Sunyer FX. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. Obes Res 1998; 6(suppl):51S–209S.
7. White HD. Scientific communication and literature retrieval. In: Cooper H, Hedges L, eds. The handbook of research synthesis. New York: Russell Sage Foundation, 1994:41–55.
8. Anderson JW, Hamilton CC, Crown-Weber E, Riddlemoser M, Gustafson N. Safety and effectiveness of a multidisciplinary very-low-calorie diet program for selected obese individuals. J Am Diet Assoc 1991;91:1582–4.
9. Anderson JW, Brinkman VL, Hamilton CC. Weight loss and 2-y follow-up for 80 morbidly obese patients treated with intensive very-low-calorie diet and an education program. Am J Clin Nutr 1992; 56(suppl):244S–6S.
10. Anderson JW, Vichitbandra S, Qian W, Krysico RJ. Long-term weight maintenance after an intensive weight-loss program. Am J Coll Nutr 1999;18:620–7.
11. Dubbert PM, Wilson GT. Goal-setting and spouse involvement in the treatment of obesity. Behav Res Ther 1984;22:227–42.
12. Ewbank PP, Darga LL, Lucas CP. Physical activity as a predictor of weight maintenance in previously obese subjects. Obes Res 1994;3: 257–63.
13. Fitzwater SL, Weinsier RL, Wollridge NH, Birch R, Liu C, Bartolucci AA. Evaluation of long-term weight changes after a multidisciplinary weight control program. J Am Diet Assoc 1991;91:421–6.
14. Flynn TJ, Walsh MF. Thirty-month evaluation of a popular very-low-calorie diet program. Arch Fam Med 1993;2:1042–8.
15. Graham LE, Taylor CB, Hovell MF, Siegel W. Five-year follow-up to a behavioral weight-loss program. J Consult Clin Psychol 1983; 51:322–3.
16. Grodstein F, Levine R, Troy L, Spencer T, Colditz GA, Stampfer MJ. Three-year follow-up of participants in a commercial weight loss program. Arch Intern Med 1996;156:1302–6.
17. Hall SM. Case histories and shorter communications. Behavioral treatment of obesity: a two-year follow-up. Behav Res Ther 1973; 11:647–8.

18. Hartman WM, Stroud M, Sweet DM, Saxton J. Long-term maintenance of weight loss following supplemented fasting. Int J Eat Disord 1993;14:87–93.
19. Haus G, Hoerr SL, Mavis B, Robison J. Key modifiable factors in weight maintenance: fat intake, exercise, and weight cycling. J Am Diet Assoc 1994;94:409–13.
20. Hensrud DD, Weinsier RL, Darnell BE, Hunter GR. A prospective study of weight maintenance in obese subjects reduced to normal body weight without weight-loss training. Am J Clin Nutr 1994;60: 688–94.
21. Holden HJ, Darga LL, Olson SM, Stettner DC, Ardito EA, Lucas CP. Long-term follow-up of patients attending a combination very-low calorie diet and behavior therapy weight loss programme. Int J Obes Relat Metab Disord 1992;16:605–13.
22. Hovell MF, Koch A, Hofstetter CR, et al. Long-term weight loss maintenance: assessment of a behavioral and supplemented fasting regimen. Am J Public Health 1988;78:663–6.
23. Jeffrey RW, Bjornson-Benson WM, Rosenthal BS, Lindquist RA, Kurth CL, Johnson SL. Correlates of weight loss and its maintenance over two years of follow-up among middle-aged men. Prev Med 1984;13:155–68.
24. Jordan HA, Canavan AJ. Patterns of weight change: the interval 6 to 10 years after initial weight loss in a cognitive-behavioral treatment program. Psychol Rep 1985;57:195–203.
25. Kirschenbaum DS, Stalonas PM, Zastowny TR, Tomarken AJ. Behavioral treatment of adult obesity: attentional controls and 2-year follow-up. Behav Res Ther 1985;23:675–82.
26. Kramer FM, Jeffrey RW, Forster JL, Snell MK. Long-term follow-up of behavioral treatment for obesity: patterns of weight regain among men and women. Int J Obes 1987;13:123–36.
27. Lavery MA, Loewry JW. Identifying predictive variables for long-term weight changes after participation in a weight loss program. J Am Diet Assoc 1993;93:1017–24.
28. Murphy JK, Bruce BK, Williamson DA. A comparison of measured and self-reported weights in a 4-year follow-up of spouse involvement in obesity treatment. Behav Ther 1985;16:524–30.
29. Nunn RG, Newton KS, Faucher P. 2.5 years follow-up of weight and body mass index values in the Weight Control for Life! Program: a descriptive analysis. Addict Behav 1992;17:579–85.
30. Pavlou KN, Krey S, Steffee WP. Exercise as an adjunct to weight loss and maintenance in moderately obese subjects. Am J Clin Nutr 1989;49:1115–23.
31. Stunkard AJ, Penick SB. Behavior modification in the treatment of obesity. The problem of maintaining weight loss. Arch Gen Psychiatry 1979;36:801–6.
32. Stalonas PM, Perri MG, Kerzner AB. Do behavioral treatments of obesity last? A five-year follow-up investigation. Addict Behav 1984;9:175–83.
33. Sikand G, Kondo A, Foreyt JP, Jones PH, Gotto AM. Two-year follow-up of patients treated with a very-low-calorie diet and exercise training. J Am Diet Assoc 1988;88:487–8.
34. Wadden TA, Stunkard AJ, Liebschutz J. Three-year follow-up of the treatment of obesity by very low calorie diet, behavior therapy, and their combination. J Consult Clin Psychol 1988;56:925–8.
35. Wadden TA, Sternberg JA, Letizia KA, Stunkard AJ, Foster GD. Treatment of obesity by very low calorie diet, behavior therapy, and their combination: a five-year perspective. Int J Obes 1989;13:39–46.
36. Wadden TA, Frey DL. A multicenter evaluation of a proprietary weight loss program for the treatment of marked obesity: a five-year follow-up. Int J Eat Disord 1997;22:203–12.
37. Walsh MF, Flynn TJ. A 54-month evaluation of a popular very low calorie diet program. J Fam Pract 1995;41:231–6.
38. Wing RR, Venditti EM, Jakicic JM, Polley BA, Lang W. Lifestyle intervention in overweight individuals with a family history of diabetes. Diabetes Care 1998;21:350–9.
39. Jackson S, Bagstaff SM, Lynn S, Yeaman SJ, Turnbull DM, Walker DM. Decreased insulin responsiveness of glucose uptake in cultured human skeletal muscle cells from insulin-resistant nondiabetic relatives of type 2 diabetic families. Diabetes 2000;49:1169–77.
40. Anderson JW, Johnstone BM, Cook-Newell ME. Meta-analysis of effects of soy protein intake on serum lipids in humans. N Engl J Med 1995;333:276–82.
41. Friedenrich CM. Methods of pooled analyses of epidemiologic studies. Epidemiology 1993;4:295–302.
42. Mosteller F, Colditz GA. Understanding research synthesis (meta-analysis). Annu Rev Public Health 1996;17:1–23.
43. Johnstone BM, Leino EV, Ager CR, Ferrer H, Fillmore KM. Determinants of life-course variation in the frequency of alcohol consumption: meta-analysis of studies from the Collaborative Alcohol-Related Longitudinal Project. J Stud Alcohol 1996;57:494–506.
44. Laird NM, Mosteller F. Some statistical methods for combining experimental results. Int J Technol Assess Health Care 1990;6:5–30.
45. Colditz GA, Burdick E, Mosteller F. Heterogeneity in meta-analysis of data from epidemiologic studies: a commentary. Am J Epidemiol 1995;142:383–7.
46. Shadish WR, Haddock CK. Combining estimates of effect size. In: Cooper H, Hedges L, eds. The handbook of research synthesis. New York: Russell Sage Foundation, 1994:261–84.
47. Wang MC, Bushman BJ. Fixed-effects models in meta-analysis. In: Wang M, Bushman B, eds. Integrating results through meta-analytic review using SAS software. Cary, NC: SAS Institute Inc, 1999: 224–72.
48. Huffcutt AI, Arthur W, Bennet W. Conducting meta-analysis using the PROC MEANS procedure in SAS. Educ Psychol Meas 1993;53: 119–31.
49. McGuire MT, Wing RR, Hill JO. The prevalence of weight loss maintenance among American adults. Int J Obes Relat Metab Disord 1999;23:1314–9.
50. Williamson DF. Descriptive epidemiology of body weight and weight changes in US adults. Ann Intern Med 1993;119:646–9.
51. Kumanyika SK, Obarzanek E, Stevens VJ, Hebert PR, Whelton PK. Weight-loss experience of black and white participants in NHLBI-sponsored clinical trials. Am J Clin Nutr 1991;53(suppl):1631S–8S.
52. Hartz AJ, Rimm AA. Natural history of obesity in 6,946 women between 50 and 59 years of age. Am J Public Health 1980;70:385–8.
53. Quinn Rothacker D. Five-year self-management of weight using meal replacements: comparison with matched controls in rural Wisconsin. Nutrition 2000;16:344–8.
54. Bouchard C, Depres JP, Tremblay A. Exercise and obesity. Obes Res 1993;1:133–47.
55. Andersen RE, Wadden TA, Barlett SJ, Zemel B, Verde TJ, Frankckowiak S. Effects of lifestyle activity vs structured aerobic exercise in obese women. JAMA 1999;281:335–40.
56. Jakicic JM, Winters C, Lang W, Wing RR. Effects of intermittent exercise and use of home exercise equipment on adherence, weight loss, and fitness in overweight women. JAMA 1999;282: 1554–60.
57. Klem ML, Wing RR, McGuire MT, Seagle HM, Hill JO. A descriptive study of individuals successful at long-term maintenance of substantial weight loss. Am J Clin Nutr 1997;66:239–46.
58. Ditschuneit HH, Flechtner-Mors M, Johnson TD, Adler G. Metabolic and weight-loss effects of a long-term dietary intervention in obese patients. Am J Clin Nutr 1999;69:198–204.