Maintenance of weight loss in obese subjects

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Bender, A. E. and Bender, D. A. (1976). *British Journal of Preventive and Social Medicine*, **30**, 60-65. **Maintenance of weight loss in obese subjects.** The records of a selected group of 215 subjects who had successfully lost surplus weight were followed-up for periods of one to six years. Mean initial weight was 131% of standard (19.5 kg surplus) and the mean time taken to achieve 'goal weight' was 7.05 months (range two to 20 months) at a mean rate of 2.9 kg per month (range 1.85 to 5 kg). Altogether 121 subjects (56.3%) maintained goal weights within ± 2.3 kg of goal; 79 subjects (36.7%) maintained within ± 4.5 kg. At the time of examination of the records, 39 subjects (18.8%) had maintained constant weight for more than four years, 22 subjects (10.6%) for three to four years, 65 subjects (31.4%) for two to three years, 58 subjects (28.5%) for one to two years, and 23 subjects (11.1%) for periods of up to one year.

The difficulties of losing surplus fat are well recognized but the difficulties of maintaining correct weight thereafter are even greater (Stunkard and McLaren-Hume, 1959; Durnin and Passmore, 1967). We examined the records of 215 subjects who had lost weight successfully while being members of the Weightwatchers' Organization and who had maintained their goal weights for periods of up to five years. They were all members of the staff of Weight Watchers' Organization and so were a selected group whose interest and motivation were greater than average. Although they are not a representative group the pattern of weight loss may be of more general application.

Since obesity is usually defined as body weight 10% greater than standard, maintenance may be arbitrarily defined as constancy within $\pm 5\%$ of standard weight.

SUBJECTS

There were 213 women and two men (mean age 40.8, range 23-68 years). Mean initial weight was 81.7 ± 14.1 kg SD, falling within the distribution shown in Fig. 1. This was 19.5 kg surplus or 131% of standard weight for height, sex, and build (Society of Actuaries, 1959) with the distribution shown in Fig. 2.

DIET

The recommended diet was based on controlled amounts of a wide variety of commonly-eaten foods, selected so as to supply all the nutritional requirements, despite the restricted energy intake. For men the daily energy intake was 1400-1600 kcal, which was approximately 65%, 50%, and 40% of the daily recommended intakes for sedentary, moderately active, and active men respectively (Department of Health and Social Security, 1969). Altogether 30-35% of the energy was supplied from protein, which exceeded the various estimates of recommended intakes (UK, USA, and World Health Organization), 25 to 30% from fat and approximately 40% from carbohydrate. The diet met or exceeded the daily recommended intake for vitamins A, B1, B2, niacin, C, and D (Department of Health and Social Security, 1969) and for vitamins B6, E, and B12 (National Research Council, 1973).

For women the energy intake advised was 1100-1400 kcal, which was approximately 50% of the daily recommended intake (Department of Health and Social Security, 1969) with the proportions supplied by protein, fat, and carbohydrate as for men; nutrients were supplied in adequate or excess amounts.

FIG. 1. Initial body weight.

FIG. 2. Body weights in 215 subjects expressed as percentages of surplus of goal weight.

The same diet was recommended for all subjects, irrespective of initial weight and desirable weight, so the energy deficit varied with the individual.

RESULTS

TIME TAKEN TO REACH GOAL WEIGHT

Goal weights were taken as the midpoint of the ranges given in the standard tables (Society of Actuaries, 1959). The mean time taken to achieve goal weight for all subjects was 7.05 months $\pm$ 3.69 SD; the mode was 3.85 months, range 2-20 months, with a single subject taking 27 months.

RATE OF LOSS

Weekly records were kept, but to avoid possible fluctuations in weights caused by deviations from the advised food intake or temporary retention of water, the mean monthly weights were used in all calculations. Mean monthly rate of weight loss was 2.9 kg $\pm$ 1.09 SD, range 1.85-5 kg per month.

There was a rapid loss of weight during the first, and occasionally during the second week. Table I shows that while the mean loss in the first week

was 2.08 ± 1.0 kg, 55 subjects (26%) lost more than 3.5 kg and three subjects lost more than 5 kg. In the second week the mean loss was 1.26 kg and six subjects (2.9%) lost more than 3.5 kg.

There was no correlation between the rate of loss during the first or second week or overall mean loss per month, and the amount of surplus weight or initial weight.

A 48-year-old man, 77% in excess of goal weight (165 kg) lost 6.35 kg during the first week and 15.2 kg during the second week. After that the average loss was 2.4 kg a week for the 26 weeks taken to reach goal weight.

A 46-year-old woman, 100.5% in excess of goal weight (156 kg) lost 9.1 kg during the first week and 2.04 kg during the second week. After that the average loss was 1.03 kg a week for the 76 weeks taken to reach goal.

A 44-year-old woman who was only 24% in excess of goal weight behaved similarly. During the first week 5.0 kg was lost and during the second week 0.9 kg. After that the average loss was 0.69 kg per week for the 28 weeks taken to reach goal.

TABLE I
WEIGHT LOSS DURING FIRST TWO WEEKS

Number of Subjects	Week 1	Week 2	Combined Weeks 1 and 2
	211	206	213
Mean loss (kg) ..	2.08	1.26	3.28
± SD ..	1.00	1.22	1.82
Mode (kg) ..	2.6	1.7	3.75
Range (kg) ..	0 to + 9.0	- 2 to + 15	- 1 to + 21
Numbers losing < 1.0 kg ..	14	49	31
Percentage of subjects ..	6.6	23.8	14.6
Numbers losing > 3.5 kg ..	55	6	2
Percentage of subjects ..	26.1	2.9	0.9
Numbers losing > 5.0 kg ..	3	1	2

As discussed later, the greater part of this early weight loss must have been fluid.

PATTERN OF WEIGHT CHANGE

In order to compare the pattern of weight loss among subjects losing weight at varying rates over differing periods of time, losses were calculated as percentage of excess weight. Graphs were then plotted of percentage of excess weight lost against percentage of time to achieve goal weight for each subject. These graphs were inspected and allocated to three groups, according to the pattern observed: (a) exponential or hyperbolic, (b) hyperbolic with one or more periods without weight loss (a 'plateau' on the weight loss curve), and (c) linear. Fig. 3 shows examples of each of these patterns. Of the 215 subjects, 70 (32.5%) were classified as fitting the hyperbolic pattern, 74 (34.4%) showed a hyperbolic pattern with plateau(x) and 17 (7.9%) showed a linear pattern of weight loss. However, 54 subjects could not be assigned to any

group, either because the graphs could not be interpreted unambiguously (22 subjects) or because the subjects had achieved goal weight within three months, and therefore presented too few points to plot reliably (32 subjects).

Since the points on the curves are monthly means of weekly weighings, a plateau was the result of failure to lose weight for at least eight successive weighings. In some subjects plateaux continued for 12 or 16 weeks or were repeated (Fig. 3).

Mean initial body weight of the hyperbolic group was 27.0% above goal weight, which was significantly less than the mean excess weight of the plateau group at 40.8% above goal ($P < 0.00001$), and also significantly less than the linear group, which was 36.1% above goal ($P < 0.01$). There was no difference between the mean excess weights of the plateau and linear groups (Table II).

The rate of weight loss in the hyperbolic and linear groups (3.02 kg and 3.3 kg respectively) was significantly greater than the rate of loss in the plateau group (2.53 kg) per month ($P < 0.0002$).

TABLE II
PATTERN OF WEIGHT LOSS*

Subjects	Hyperbolic	Plateau	Linear
Number ..	70	74	17
Percentage ..	32.5	34.4	7.9
Excess weight ..	27.0(a)	40.8(b)	36.1(c)
± SD ..	± 9.56	± 16.8	± 13.0
Rate of loss kg/month ..	3.02(d)	2.52(e)	3.3 (f)
± SD ..	± 0.80	± 0.79	± 0.70

*54 subjects (25%) undefinable
ab $P = 0.0002$
bc $P = 0.0001$
ef $P = < 0.00001$
df $P = 0.0087$

FIG. 3. Patterns of weight loss (time to goal, %).

MAINTENANCE OF GOAL WEIGHTS

Subjects varied in their ability to maintain 'constant' weight; 121 subjects (56.3%) maintained weight within 2.3 kg of goal; 79 (36.7%) within 4.5 kg; 15 subjects (7%) fell outside this range.

At the time records were examined 23 subjects (11.1%) of the 207 for whom the information was available had maintained goal weights for periods of up to one year, 58 subjects (28%) for one-two years, 65 subjects (31.4%) for two-three years, 22 subjects (10.6%) for three-four years, 32 subjects (15.4%) for four-five years, and seven subjects (3.4%) for five-six years. These periods were solely a reflection of the length of time the subjects had been members of the Weightwatchers' Organization.

Examples of maintenance for long periods (72 and 43 months), between narrow limits are shown in Figs 4A and B. The subject in Fig. 4A maintained constant weight within ± 1 kg.

AGE AT ONSET OF OBESITY

Records were examined to ascertain whether any of the observations related to the age at which subjects first became obese. It was necessary to rely upon evidence supplied by the subjects. Of the 94 subjects who supplied such information, 11.7%

had been fat from babyhood, 18.1% gave the age of onset as between one and 10 years, 30.9% between 11 and 20 years, 33% between 21 and 30 years, and 6.4% between 31 and 40 years.

No correlation was found between the age at which subjects first became obese and the following: initial weight loss in first and second weeks, time taken to achieve goal weight, mean monthly weight loss, initial body weight, excess weight, or excess weight expressed as a percentage of goal weight. Subjects obese from infancy did not differ in any of these respects from those reported to have become obese at later ages.

DISCUSSION

GOAL WEIGHT

Standard weight tables are the means of 'desirable' weights drawn up by the Metropolitan Life Assurance Company. They do not necessarily coincide with the desirable weight of an individual subject. Moreover, while the tables establish weights for small, medium, and large body frames such classification appears to be a matter of subjective assessment. In the present study the assessment was made by the Weight Watchers' class lecturer.

In some instances subjects, after losing a large part of their surplus weight, maintained constant

FIG. 4 A B. Examples of maintenance of weight for a long period.

weight for long periods several kilograms above their goal weights. In other instances, subjects maintained constant weight for long periods below their goal weights. For example, three subjects remained 3.6 kg above goal weight for periods of between 19 and 49 months; two subjects remained 3.6 kg below goal weight, one for 25 and the other for 26 months; five subjects varied in weight from goal to 5.5 kg below goal for periods of between 20 and 36 months. Since 185 subjects (86% of the total number) reached and maintained goal weights which were set at the single figure at the midpoint of the range given in the tables, it appears possible that those who plateaued above or below the arbitrary average goal had, in fact, reached their personal goal. For 19 subjects goal weights were changed on the advice of their medical practitioners. There is no standard on which to base an individual's correct weight, the only indication would appear to be a prolonged weight plateau. Such a plateau may not, however, reflect the 'correct' weight if the subject is making intensive efforts to maintain the given target. For example, the subject referred to in Fig. 4A who had maintained weight within 1 kg of goal for 72 months stated that this was the result of careful control of her diet.

RATE OF WEIGHT LOSS

The rate of weight loss, assuming a constant energy intake, is the result of several factors. Since a heavier individual uses more energy for movement (Bloom and Eidex, 1967), the energy deficit becomes progressively smaller as weight is lost. At the same time, fat people are generally less active than thin ones (Bloom and Eidex, 1967) so that weight reduction may be accompanied by increased activity. In addition, the subject can adapt to an energy deficit by reducing the basal metabolic output (Bray, 1969).

If the first of these effects predominates the weight curve would be hyperbolic; if the second predominates weight loss should approximate to a straight line; adaptation would lead to a plateau. There is evidence in the literature for all three patterns of weight change; in the present series of observations some subjects fell into each of these three groups, but only a small number (7.9% of the sample) lost weight in linear fashion.

Lyon and Dunlop (1932) showed that early weight losses tended to slow down and they quoted Luciana (1890) who suggested a parabolic formula. This was supported by the findings of Benedict (1915). Young *et al.* (1955) observed a parabolic

pattern of weight change in 60 subjects during a 24-week period.

On the other hand, Bortz (1968) predicted straight-line weight losses and showed that 40 patients followed this prediction. He calculated that to maintain weight, each 11.3 kg (25 lb) excess weight required an extra 100 kcal so that the energy deficit would fall by only this amount for each 11.3 kg of weight lost. Since this was supplied by 66 g (0.03 lb) of adipose tissue the author considered the change to be an insignificant deviation from a straight line. There are, however, two points on which to discount these figures. First, a discrepancy of 66 g per day amounts to approximately 0.5 kg in a month, so the weight change should be parabolic in the long term. Secondly, using the Food and Agriculture Organization's formula for daily energy expenditure of women ($580 + 31.1 W$), a difference of 11.3 kg in body weight amounts to approximately 350 kcal per day not 100 kcal.

The weight loss patterns suggest that the heavier subjects (plateau group) had greater difficulty in losing weight. There is no evidence that they adhered to the prescribed diet but if they did they had greater difficulty in losing weight, and if they did not, they apparently had greater difficulty in adhering to the diet. This group was significantly heavier initially with 40.8% surplus weight, than the hyperbolic group with 27% surplus, but not significantly heavier than the much smaller linear group with 36% surplus weight.

Initial weight loss was much greater than the average rate. Altogether 55 subjects (26%) lost 3.5 kg during the first week compared with an overall average of 0.7 kg a week. One subject lost 21.5 kg in two weeks. This has frequently been observed and attributed to loss of fluid when carbohydrate intake is reduced, but which can be regained on isocaloric diets when carbohydrate intake is increased (Olesen and Quaade, 1960; Pilkington *et al.*, 1960; Bloom and Azar, 1963).

ADHERENCE TO DIET

Negative energy balance must, by definition, lead to loss of weight. The failing of most 'slimmers' is the failure to adhere to the recommended diet. Matsuki and Yoda (1971) stated that few of their 'successful' cases attained normal weight range and they attributed this to the prolonged effort needed and the lack of zeal of the subjects. Two of the factors involved are unattractiveness of the diet and lack of supervision, indeed, Matsuki and Yoda stated that it was a characteristic of obesity that weight increased when supervision

was removed. Some of these problems are alleviated by the dietary programme compiled by the Weightwatchers' Organization, which fulfils four criteria:

1. A large selection of common food items is recommended—for example, 80 different vegetables, 40 different fruits, and 70 different foods of the meat-fish-offal-poultry group—as well as foods such as bread, rice, and pasta which are usually prohibited in energy-restricted diets.
2. Methods of cooking and presentation are intended to make the food attractive and overcome the possibility of monotony.
3. By replacing high-energy with low-energy foods the volume of food consumed is not reduced so that the subjects have less cause to feel dissatisfied with the diet.
4. The selection of foods ensures an adequate intake of all nutrients, a condition not easily achieved when the diet is reduced to two-thirds of the normal energy content.

Finally, the programme is based on the positive precepts of what must be eaten rather than on the negative approach of forbidden foods.

The subjects reported on here were supervised closely during their period of weight loss by the Weightwatchers' routine of weekly advisory meetings and continuous access to a supervisor who has passed through the same experiences of being overweight. After they had reached goal weight these subjects themselves became members of the Organization as lecturers and so had an incentive to maintain their 'proper' weight. Under these conditions the 215 subjects were certainly more successful than would seem possible from the conclusions drawn earlier (Cornell Conferences on Therapy, 1958) namely, 'most obese patients will not remain in treatment. Of those who do remain in treatment, most will not lose significant poundage, and of those who do lose weight, most will regain it promptly'.

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REFERENCES

- BENEDICT, F. G. (1915). Carnegie Inst. Wash. Publ. No. 203.
- BLOOM, W. L. and AZAR, G. J. (1963). Similarities of carbohydrate deficiency and fasting. *Arch. intern. Med.*, **112**, 333.
- and EIDEX, M. F. (1967). The comparison of energy expenditure in the obese and lean. *Metabolism*, **16**, 685.
- BORTZ, W. M. (1968). Predictability of weight loss. *J. Amer. med. Ass.*, **204**, 101.
- BRAY, G. A. (1969). Effect of caloric restriction on energy expenditure in obese patients. *Lancet*, **2**, 397.
- CORNELL CONFERENCES ON THERAPY (1958). The management of obesity. *N. Y. St. J. Med.*, **58**, 79.
- DEPARTMENT OF HEALTH AND SOCIAL SECURITY (1969). *Recommended Daily Intakes for Energy and Nutrients for UK*. HMSO, London.
- DURNIN, J. V. G. A. and PASSMORE, R. (1967). *Energy, Work and Leisure*. Heinemann, London.
- LUCIANA, L. (1890). *Das Hungern*, Hamburg.
- LYON, D. M. and DUNLOP, D. M. (1932). The treatment of obesity: a comparison of the effects of diet and thyroid extract. *Quart. J. Med.*, **1**, 331.
- MATSUKI, S. and YODA, R. (1971). Obesity in the Japanese: its prevalence and major complications. *Keio J. Med.*, **20**, 127.
- NATIONAL RESEARCH COUNCIL (1973). US Food and Nutrition Board. *Recommended Daily Dietary Allowances*.
- OLESEN, E. S. and QUADE, F. (1960). Fatty foods and obesity. *Lancet*, **1**, 1048.
- PILKINGTON, T. R., ROSENOER, V. M., GAINSBOROUGH, H., and CAREY, M. (1960). Diet and weight reduction in the obese. *Lancet*, **1**, 856.
- SOCIETY OF ACTUARIES (1959). *Build and Blood Pressure Study*.
- STUNKARD, A. and McLAREN-HUME, M. (1959). The results of treatment for obesity: a review of the literature and report of a series. *Arch. intern. Med.*, **103**, 79.
- YOUNG, C. M., MOORE, N. S., BERRESFORD, K., EINSET, B. M., and WALDNER, B. G. (1955). Problem of obese patients. *J. Amer. diet. Ass.*, **31**, 1111.