Reducing diets

Weight loss of obese patients on diets of different composition

BY R. F. FLETCHER, MARJORIE Y. McCRIRICK AND A. C. CROOKE
Metabolic Research Unit, Little Bromwich General Hospital, Birmingham 9

(*Received 12 April 1960—Revised 11 August 1960*)

There is no definite evidence of any abnormality of intestinal function, fat deposition and mobilization or energy metabolism in simple obesity (Newburgh, 1944; Conn, 1944). The only known means by which an obese person can lose fat, other than by surgical excision, is to convert it into energy, which conversion occurs only when there is a negative calorie balance.

The prescription of a low-calorie diet for weight reduction is successful if the patient can be persuaded to adhere to it. It is generally agreed that the lower the calorie intake the faster the loss of weight will be, but the most desirable level of calorie intake is uncertain. Perhaps the greatest difficulty is in constructing a diet that will be both palatable and acceptable, the latter being essential if the patient is to keep to the regimen. In such a subjective matter considerable individual variation is probable. Again, the rate of loss of weight may depend to some extent on the qualitative composition of the diet (Kekwick & Pawan, 1956) and the investigation now reported was designed to test this hypothesis.

An experimental design permitting rigorous statistical analysis of the results has been used. It was not possible to carry out balance studies so the loss in body-weight was used as the criterion of effectiveness of the diets.

EXPERIMENTAL

Patients. The personal details and basal metabolic rates of the six women examined are shown in Table 1. They all had moderate or severe simple obesity without evidence of endocrine or intracranial disease. Physical examination, radiography of chest and sella turcica, urine composition, blood count, erythrocyte sedimentation rate, serum cholesterol and proteins were normal.

The women were unselected except in that they agreed to a prolonged hospital admission and that such an admission was thought justified either because of the degree of obesity or, in patient no. 6, the earnest desire to lose weight. All had made previous attempts at weight reduction and had relapsed. None had borne children except no. 2, who had had six. Three patients admitted to the trial were later rejected. One was found to have hyperadrenocorticism, one was pubertal and the third could not tolerate the diet.

Measurements. The patients were weighed each morning after passing urine at about 8.30 a.m. wearing only a nightdress. An Avery seat scale, the accuracy of which was checked at intervals, was used and the weights were recorded to the nearest 100 g. Patient no. 4 was too heavy for this scale and was weighed on a platform scale of greater capacity.

Basal oxygen consumption and metabolic rate were estimated by a standard technique (Harrison, 1958). Expected weights were taken from the tables of the medico-actuarial mortality investigation (Davenport, 1923).

Environment. The patients were in a metabolic ward under close supervision and it is unlikely that they obtained any additional food. They spent each morning in bed but were up and dressed for the rest of the day. They took short walks in the hospital grounds but no other exercise. They received four Capsules Vitaminorum (N.F. 1949) providing daily: vitamin A 10 000 i.u., thiamine hydrochloride 2·0 mg, riboflavin 2·0 mg, nicotinamide 30·0 mg, ascorbic acid 60·0 mg and vitamin D 1200 i.u., and Preludin (C. H. Boehringer Sohn, Ingelheim am Rhein), a suppressor of appetite, 50 or 100 mg/day, but no other medicaments except occasional mild analgesics.

Table 1. *Information about the six women*

Patient no.	Age (years)	Height (cm)	Weight on admission: kg	Weight on admission: Percentage above expected	Basal oxygen consumption (ml/min at s.t.p.)	Basal metabolic rate (%)
1 (20069)*	21	156·0	96·0	78	238	−4
2 (20027)	60	156·0	121·0	95	226	−7
3 (14917)	21	163·0	127·0	122	237	−13
4 (28731)	22	171·5	154·0	144	308	+10
5 (15859)	40	158·0	112·0	87	229	−5
6 (17341)	28	168·5	87·0	38	266	+13

* Little Bromwich General Hospital admission number.

Table 2. *Composition and food values of the 500 kcal basic diet for a single day*

Food	Quantity	Protein (g)	Fat (g)	Carbohydrate (g)	Calories (kcal)
Methylcellulose biscuits	3	1·8	2·1	15·0	90
'Diabetic' fruit squash	100 ml	0	0	4·0	18
Lean beef (or occasionally lean mutton)	50 g	13·4	6·2	0	112
Cheese (or egg)	50 g (130 g)	12·5	17·3	0	211
Cabbage	50 g	0·7	0	0·5	5
Tomato	75 g	0·7	0	2·0	10
Apple	75 g	0·2	0	9·0	35
Orange	75 g	0·6	0	6·0	26
Total	—	29·9	25·6	36·5	507

Diets. A basic diet of 500 kcal/day was given throughout the patients' stay in the hospital but certain supplementary foods (see below) were added in accordance with the experimental design. All the food was prepared and weighed in a diet kitchen.

Water was allowed freely but no salt was used in the cooking and no added salt was permitted. One methylcellulose biscuit (Melozets; Merck, Sharp & Dohme, Hoddesdon, Herts) was given each day at 7.30 a.m., 3.00 p.m. and 9.30 p.m. The food was given in two meals at noon and 5.30 p.m. The composition of 1 day's basic diet is shown in Table 2. The food values were taken from the tables of McCance & Widdowson (1946) except for the first two items, for which the manufacturers' analyses were used.

Diet supplements. Three different supplements were given, each yielding about 300 kcal/day: protein as 83 g Casilan (Glaxo Laboratories Ltd, Greenford, Middx), fat as 39 g butter and carbohydrate as 71 g sugar.

Each day's supplement was divided into three parts and given with the three methylcellulose biscuits. The butter was spread on the biscuits. The sugar was dissolved in 400 ml water with 50 ml pure lemon juice. Casilan was mixed with 450 ml water in an electric blender. The last two supplements were given as drinks. The proportions of each diet in terms of calories are shown in Table 3.

Table 3. *Proportions of protein, fat and carbohydrate in each diet in terms of calories*

Diet	Calories (kcal)	From protein (%)	From fat (%)	From carbohydrate (%)
Basic: unsupplemented	507	24	47	29
with casilan	814	**53**	29	18
with butter	817	15	**67**	18
with sugar	788	16	30	**54**

Experimental design. On admission the patients were given the basic diet providing 500 kcal for a preliminary period of 8–30 days. During the next 6 weeks each patient received the three supplements separately and in turn. A period of 14 days was used for testing each supplement and there was no interval between the periods. The programme for each experimental period was identical. On the 1st day the patient had only the methylcellulose biscuits and 'diabetic' fruit squash; for the next 13 days the basic diet with one of the supplements was given.

The total weight loss while the patients were receiving each supplement was taken as the difference between the weight on the day of starvation at the beginning of the period and the weight on the next day of starvation 2 weeks later. All the periods were thus strictly comparable.

The sequence in which the supplements were given was different for each patient. The experiment was randomized by drawing up a table of the six possible sequences before the trial began. As each patient was admitted to the trial she was assigned to the next unused sequence.

In short, after an initial period of rapid weight loss on a conventional low-calorie diet each patient was given three diets in which more than half the calories were supplied by protein, fat or carbohydrate respectively in different sequences.

RESULTS

In this study no more than ordinary attention was directed at the acceptance of the diets by the patients, hunger and subsequent weight trends. However, all the patients remained active, reasonably contented during their stay in hospital and were delighted with their loss of weight.

During the initial period on the 500 kcal diet there was a rapid loss of body-weight in each patient. The initial body-weight at the beginning of the 6-week test period, the weight at weekly intervals thereafter and the supplement given are shown in Table 4. It was noted that there was a statistically significant correlation between the total weight lost in the 6 weeks and the body-weight at the beginning of the first period ($r = 0·89$; $P < 0·001$). That is, the loss of weight tended to be greater when the initial weight was greater.

Table 4. *Weight (kg) of each patient at weekly intervals and nature of the supplement to the basic diet in each period. The weight loss (kg) for each period is shown in parentheses*

Patient no.	Period 1		Period 2		Period 3		
1	Protein (3·0)		Fat (3·2)		Carbohydrate (1·4)		
	92·1	90·4	89·1	87·1	85·9	85·4	84·5
2	Carbohydrate (3·4)		Protein (2·5)		Fat (2·3)		
	114·7	113·2	111·3	109·5	108·8	107·3	106·5
3	Fat (3·2)		Protein (4·0)		Carbohydrate (1·9)		
	122·8	121·2	119·6	117·2	115·6	114·5	113·7
4	Carbohydrate (3·6)		Fat (5·2)		Protein (2·7)		
	142·4	140·5	138·8	135·5	133·6	132·0	130·9
5	Protein (3·7)		Carbohydrate (3·9)		Fat (2·3)		
	106·5	104·3	102·8	100·1	98·9	97·0	96·6
6	Fat (2·8)		Carbohydrate (0·7)		Protein (2·6)		
	83·0	81·8	80·2	80·3	79·5	78·1	76·9

Table 5. *Table of analysis of variance of differences between log weight at beginning and end of each experimental period*

Source of variation	Degrees of freedom	Sum of squares	P
Patients	5	0·0000237	> 0·25
Periods	2	0·0000535	0·25
Diets by composition	2	0·00004007	> 0·25
Residual	8	0·00012260	—

It seemed likely that a similar correlation would exist during loss of weight in the individual patient. In order to exclude this relationship from the statistical analyses the $\log_{10}$ of all the weights were taken and the analyses performed on these transformed data.

The resulting analysis of variance is shown in Table 5. No statistically significant difference could be demonstrated between the loss of weight associated with any of the components, i.e. (1) patients; (2) periods; (3) diets, by composition.

DISCUSSION

The immediate loss of weight that occurs when a low-calorie diet is first eaten (Strong, Passmore & Ritchie, 1958) is so rapid that it is reasonable to suppose that much of it is due to a loss of water. This phase is of limited duration and seems irrelevant to the subsequent slower loss of weight on the same diet. It was thought preferable that the patients should pass through this initial phase before the experiment was begun. The variation in the length of the initial period was for administrative reasons only.

The day of almost complete starvation at the beginning of each experimental period was intended to reduce any possible metabolic effects which might have persisted from the previous diet.

The positive finding was the correlation between weight lost and initial weight. At first sight it might appear likely that for a given calorie intake a certain weight loss would result but it has been known for many years (cf. Strang, 1959) that the heavier the patient the faster is the loss of weight on a reducing diet. More recently this observation has been confirmed by experiment (Young, Brown, Empey & Turk, 1958; Grossman & Sloane, 1955). The finding becomes reasonable in physiological terms when it is recalled that with increasing body-weight basal oxygen consumption, and therefore basal calorie requirement, rises (Strang & Evans, 1928). Some studies of reducing diets fail to make allowance for these facts in the analysis of the results.

The loss of weight with the carbohydrate diet was slightly less on average than with the other diets, particularly in the third period, but the statistical analysis showed that this effect could easily have arisen by chance.

The type of analysis of variance used here has been criticized (Healy, 1959) because the residual term includes any variance due to interaction between the components. As the experimental design in this instance was a double Latin square without replication, further analysis of the interactions was not possible.

The results of clinical studies of the type reported should be viewed with caution because the effectiveness of the diets is judged by the weight change. The objective of the reducing diet is to remove fat, but part of the loss of weight is known to be due to changes in other tissues (Keys & Brožek, 1953; Passmore, Strong & Ritchie, 1958; Wishnofsky, 1958).

Using experimental periods of 7 days and diets including 90% of the principal component, Kekwick & Pawan (1956) found that, with intakes of 1000–2000 kcal, a high-carbohydrate diet produced slower loss of weight and sometimes gain of weight, compared with high-fat and high-protein diets. Pilkington, Gainsborough, Rosenoer & Carey (1960) found that when a high-carbohydrate reducing diet was begun the rate of loss of weight fell, but later increased to the same rate as that observed with other diets. A high-fat diet had an opposite but less marked effect. Olesen & Quaade (1960) also found an initial accelerated loss of weight with a high-fat diet but over a period of 3 weeks there was no difference between the effect of a high-fat and a high-carbohydrate diet.

In long-term studies on active persons Cederquist, Brewer, Beegle, Wagoner, Dunsing & Ohlson (1952) found that a low-fat reducing diet caused a slower loss of weight partly because of a decrease in energy expenditure, whereas a low-carbohydrate diet maintained a sense of well-being and caused a more rapid loss of weight. Werner (1955) found no difference between high-carbohydrate and high-fat diets and Dole (1957) concluded that the protein content of a reducing diet was unimportant provided minimum requirement was met.

In the present study despite the rigorous experimental design the differences between the effects of the diets were too small to be detected. Good loss of weight resulted from all the diets. The implication is that in constructing a reducing diet, after the calorie intake has been decided and minimal nutritional requirements met (Jollife, 1956), the composition can be determined primarily by palatability and individual choice.

SUMMARY

1. Six women with simple obesity were given diets providing 800 kcal daily in which the greater part of the calories was from carbohydrate, protein or fat. A strict randomized experimental design was used.

2. Statistical analysis showed no significant difference in the rate of weight loss on the different diets. There was a positive correlation between the weight lost and the initial weight.

We wish to thank the cooks of the metabolic unit for their care in preparing the diets, and Professor H. E. Daniels and Mr T. Colton for advice on statistics.

REFERENCES

Cederquist, D. C., Brewer, W. D., Beegle, R. M., Wagoner, A. N., Dunsing, D. & Ohlson, M. A. (1952). *J. Amer. diet Ass.* **28**, 113.
Conn, J. W. (1944). *Physiol. Rev.* **24**, 31.
Davenport, C. B. (1923). *Publ. Carneg. Instn*, no. 329.
Dole, V. P. (1957). *Amer. J. clin. Nutr.* **5**, 591.
Grossman, M. I. & Sloane, H. S. (1955). *Amer. J. clin. Nutr.* **3**, 403.
Harrison, G. A. (1958). *Chemical Methods in Clinical Medicine*, 4th ed., p. 542. London: Churchill.
Healy, M. J. R. (1959). *Qualitative Methods in Human Pharmacology and Therapeutics*, p. 9. London: Pergamon Press.
Jollife, N. (1956). *J. Amer. med. Ass.* **161**, 1633.
Kekwick, A. & Pawan, G. L. S. (1956). *Lancet*, **271**, 155.
Keys, A. & Brožek, J. (1953). *Physiol. Rev.* **33**, 245.
McCance, R. A. & Widdowson, E. M. (1946). *Spec. Rep. Ser. med. Res. Coun., Lond.*, no. 235.
Newburgh, L. H. (1944). *Physiol. Rev.* **24**, 18.
Olesen, E. S. & Quaade, F. (1960). *Lancet*, i, 1048.
Passmore, R., Strong, J. A. & Ritchie, F. J. (1958). *Brit. J. Nutr.* **12**, 113.
Pilkington, T. R. E., Gainsborough, H., Rosenoer, V. M. & Carey, M. (1960). *Lancet*, i, 856.
Strang, J. M. (1959). In *Diseases of Metabolism*, 4th ed., p. 529. [G. G. Duncan, editor.] London: W. B. Saunders Co.
Strang, J. M. & Evans, F. A. (1928). *J. clin. Invest.* **6**, 277.
Strong, J. A., Passmore, R. & Ritchie, F. J. (1958). *Brit. J. Nutr.* **12**, 105.
Werner, S. C. (1955). *New Engl. J. Med.* **252**, 661.
Wishnofsky, M. (1958). *Amer. J. clin. Nutr.* **6**, 542.
Young, C. M., Brown, A. M., Empey, E. L. & Turk, D. (1958). *J. Nutr.* **64**, 203.

Printed in Great Britain