RESISTANCE TO SLIMMING
ADAPTATION OR ILLUSION?

D. S. MILLER
Queen Elizabeth College, London W8 7AH

SALLY PARSONAGE
Slimming Advisory Services, London SW1H 0RA

Summary Twenty-nine women who claimed that they could not lose weight on prescribed diets were isolated in a country house and fed 1500 kcal. per day for 3 weeks. Nine women maintained weight within ± 1 kg. and were characterised by low basal (B.M.R.) and daily metabolic rates and by a long previous history of dieting. The remaining women did lose weight, but there was much individual variation. B.M.R. is a good indicator of probable weight loss as a result of dieting. In the group as a whole it was more closely related to body fat than to lean body mass. It was also related to fat-cell number as determined by biopsy, but not to fat-cell size. These findings suggest that among a group of would-be slimmers who claim to be unable to lose weight there will be some who have become metabolically adapted to a low-energy diet and others whose inability to lose weight is illusory.

Introduction

IT is a common clinical observation that some people cease to lose weight after long periods of dieting, but the proposition has not been established under controlled conditions. There are two possible explanations; either the subjects are not following the diet or they have become metabolically adapted to it. If the diet is not being followed, this may be because the dieters are ignorant of food values or because they are deluding themselves, consciously or subconsciously. Thus some slimmers are convinced that one chocolate can cause large weight gains but that steak is always slimming; some have amnesia about their deviations from the diet; others are just liars.

On the other hand, there is some evidence that a prolonged reduction in energy intake in lean people can cause a lowering in energy expenditure.[1] Martinaud and Trémolieres [2] have shown that some obese people have depressed basal metabolic rates (B.M.R.), and Apfelbaum et al.[3] have recorded a 20% reduction in B.M.R. as a result of severe dieting. It is thus possible that there is an adaptation to undernutrition causing a resistance to slimming, similar to the adaptation to overnutrition which causes a resistance to the consequences of gluttony.[4] Simms et al.[5] have shown that the energy requirement to maintain weight in obese patients is 35% below normal whereas overfed lean individuals have a requirement 35% above normal.

We have tried to establish whether slimmers claiming to be unable to lose weight were metabolically different or just not following their diets.

Volunteers and Methods

Selection

The participants were selected from eight thousand women attending slimming clubs throughout the United Kingdom. Only women who had been attending a club for more than 6 months were considered, and then only those who had lost weight at the start of their dieting regimen but who later were apparently unable to lose weight on a low-energy diet. The final selection was made individually in an attempt to exclude those who were obviously not following their prescribed diet. Thus all these women were known to have had a low calorie intake for some time (average membership of slimming club 15 months, range 7–60 months) since they had all lost at least 7 kg. from their maximum weight (average loss 23 kg., range 7–51 kg.). They now claimed to be unable to lose weight on a normal low-calorie diet of 1000–1500 kcal. per day. By selecting women from slimming clubs it was possible to obtain detailed records of their weight losses since joining the club, rather than relying on information supplied by the slimmers themselves. Twenty-nine women were selected (table I).

TABLE I—CHARACTERISTICS OF SLIMMERS

—	Mean	Range
Age (yr.)	45	25–65
Height (cm.)	162	151–173
Weight (kg.)	72	55–118
Ideal weight (%)	126	100–220
Fat (%)	39	30–46

Control of Food Intake

To control food intake throughout the 3 weeks of the experiment, the women stayed in an isolated country house. On arrival their baggage was searched to ensure that no food was brought in, and during the experiment they had no access to food other than that provided as the diet. They were allowed complete freedom in the grounds of the house but were only permitted further afield when accompanied by a member of staff. When not involved in measurements being made in the course of the experiment, the women followed a programme of beauty and relaxation treatments. Lectures and discussions were arranged in the evenings. Thus their time was fully occupied throughout, allowing constant supervision. The preparation and serving of all meals were controlled by a dietitian, individual portions and plate waste being weighed at all times. A diet calculated to provide 1500 kcal. per day was given. During the experiment, seven duplicate samples of a complete day's food intake were collected and analysed by bomb calorimetry[6]: these showed a mean daily intake of 1350 kcal. metabolisable energy (i.e., 10% lower than calculated). This difference was probably due to the variable cooking procedures. Nevertheless the energy intake was taken to be 1500 kcal. per day since this represents a maximum intake and most values were calculated.

Body Weight and Composition

The women were weighed every morning after getting up and emptying bladders, but before breakfast. At the beginning and end of the experiment, body-fat content was assessed using Harpenden skinfold calipers by the method described by Durnin and Rahman.[7] Using these workers' tables, body fat was estimated from the total skinfold thickness of the four sites measured (biceps, triceps, subscapular, and suprailiac).

B.M.R.

B.M.R. was measured at least three times during the experiment. The measurements were taken after a 13-hour overnight fast; after the slimmers had been awakened expired air was collected for 15 minutes in a Douglas bag, and the total volume of expired air measured in a Parkinson-Cowan gas meter. A sample of the expired air was analysed for oxygen using a Servomex analyser. Gas volumes were converted to standard temperature, pressure, and the energy expenditure was calculated by the formula given by Weir [8] and the B.M.R. was expressed in kcal. per minute.

Energy Cost of Standard Exercise

The energy cost of work on a bicycle ergometer was measured at least twice. The subjects were required to work at 1·5 kp pedalling at the rate of 100 r.p.m. Expired air was collected by Douglas bag after 5 minutes on the bicycle, during which time frequent checks were made to ensure that the correct work-rate was being maintained. The metabolic-rate was calculated as described for B.M.R.

Total Daily Energy Expenditure

Diary-card method.—Each woman kept diary-card records of her activities minute by minute on 7 consecutive days during the second half of the experiment. During the same period the energy costs of her activities were determined using Kohfranyi-Michaelis respirometers.

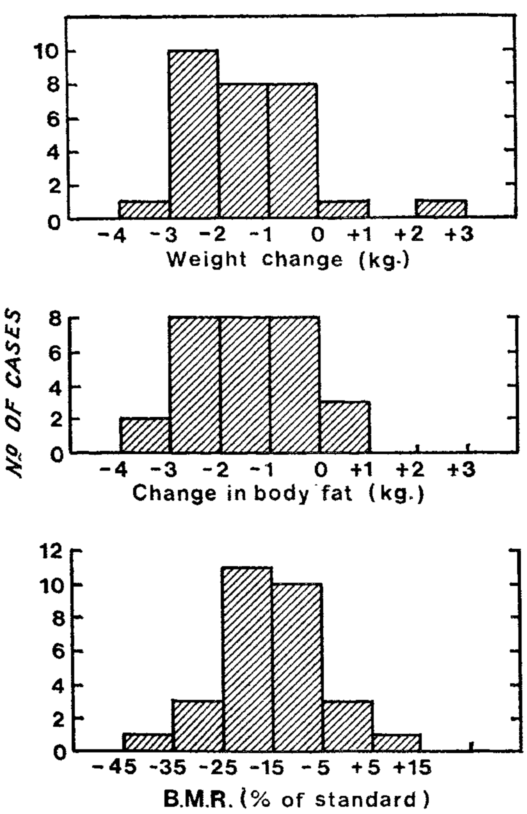

Fig. 1—Changes in weight and body fat and B.M.R. (relative to Harris-Benedict standards).

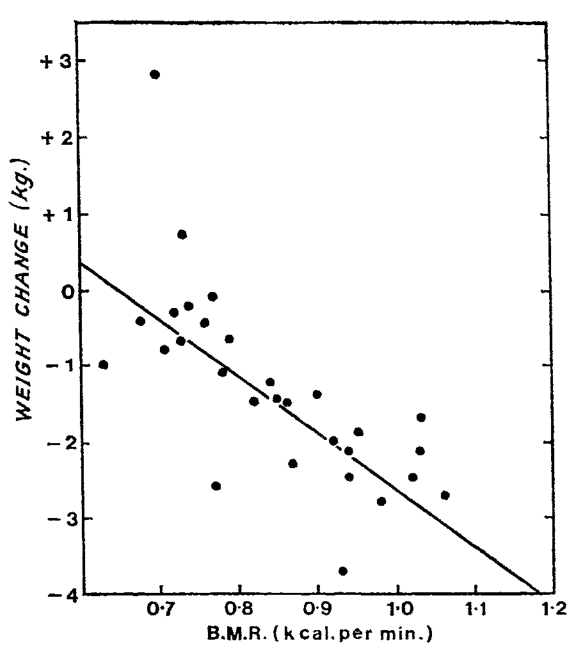

Fig. 2—Correlation between weight change and B.M.R. r = 0·68.

TABLE II—CORRELATIONS BETWEEN WEIGHT LOSS AND INDICATORS OF ENERGY EXPENDITURE

Indicator	r	P
Lying, fasting	0·68	0·00005
Lying, postprandial	0·46	0·012
Sitting	0·44	0·016
Walking	0·24	N.S.
Cycling	0·26	N.S.
Total expenditure by diary card	0·69	0.00003
Total expenditure by fat balance	0·70	0.00002

Thus for each woman a mean value for daily energy expenditure during this 7-day period was calculated.

Fat-balance method.—This method is based on the energy-balance equation $\Delta S = I - E$, where $\Delta S = \Delta$ body-fat content $\times 9$ = change in energy stores and I and E are energy intake and expenditure, respectively. Therefore $E = I - \Delta S$. Since the body-fat content was determined at the beginning and end of the experiment and the food intake was measured throughout, the mean daily energy expenditure could be calculated.

Results

Nine women maintained weight within ± 1 kg. over the 3-week period, nineteen lost weight, and one gained. Fig. 1 also shows that ten women maintained their body fat within ± 1 kg., and nineteen lost fat.

The mean B.M.R. was 0·84 (S.E.M. 0·022) kcal. per minute. The values were on average 16% below those calculated from the Harris-Benedict equation, and the range of values is also shown in fig. 1. The mean ($\pm$S.E.M.) energy costs of sitting, walking, and cycling were, respectively, $1 \cdot 16 \pm 0 \cdot 04$, $4 \cdot 6 \pm 0 \cdot 14$, and $4 \cdot 6 \pm 0 \cdot 11$ kcal. per minute.

Discussion

About a third of the women could not lose weight on the diet provided, thus confirming the existence of some individuals who have a remarkably low energy requirement for weight maintenance. How do they do it? Table II shows the correlation coefficients obtained when weight loss is related to indices of

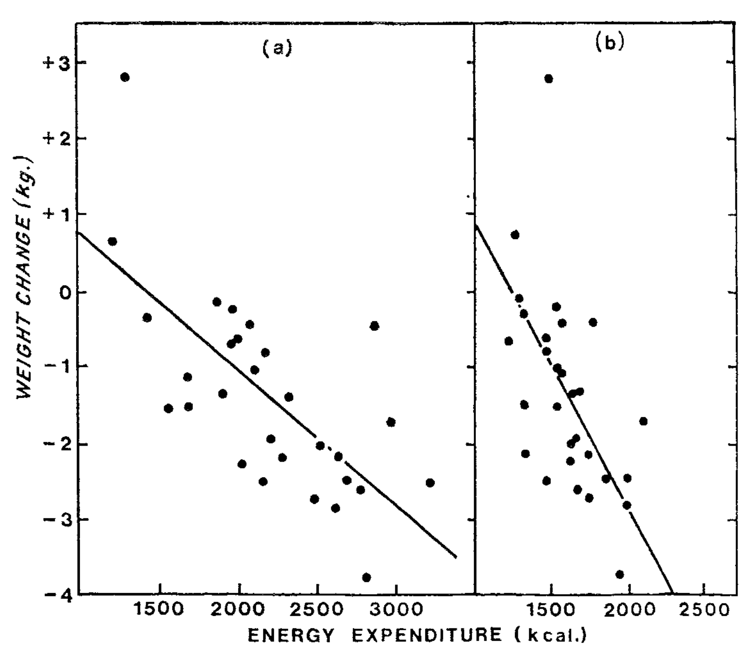

Fig. 3—Correlations between weight change and energy expenditure.

(a) Energy expenditure from fat balance ($r = 0 \cdot 70$, slope 10 kcal. 1 g.); (b) energy expenditure from diary card ($r = 0 \cdot 69$, slope 5 kcal. 1 g.).

TABLE III—CORRELATIONS OF B.M.R. OF SLIMMERS

—	r	P
Lean body mass	0·33	N.S.
Fat	0·52	0·004
Weight (W)	0·47	0·011
$W^{3/4}$	0·47	0·010
Cell size	0·15	N.S.
Cell number	0·57	0·025

energy expenditure. The most significant relationships are for B.M.R. and total energy expenditure (figs. 2 and 3). Those who genuinely could not lose weight could have been identified by determining their B.M.R. before the trial. However, none of the women showed any external sign of hypothyroidism. Fifteen women had B.M.R.s more than 15% below the Harris-Benedict standard, but it should be pointed out that these and other standards were devised excluding the obese. Low B.M.R. values have been reported by other workers for obese people.[2,3]

Bray et al.[10] have claimed that the B.M.R. in the obese is more closely related to body fat than to lean body mass, and our data support this view. Table III shows the correlation coefficients between various indices and B.M.R. The relationship with body fat is highly significant whereas that with lean body mass is not significant. This finding may merely reflect the lowering of B.M.R. due to extended dieting, but we found no significant correlation between B.M.R. and the duration of previous dieting as ascertained by membership of the slimming club. The relationship between body fat and B.M.R. is thus difficult to interpret. The metabolic activity of adipose tissue cannot be ignored in the light of recent work, but is still lower than that of muscle. However, in this study there are good correlations between B.M.R. and weight and between B.M.R. and $W^{3/4}$ (i.e., metabolic body size[11]). This suggests that the metabolic activity of fat is equal to that of the rest of the body. Fifteen women agreed to adipose-tissue biopsy, and samples were analysed. No correlations were obtained with cell size, but there was a significant relationship between fat-cell number and B.M.R. This finding is reasonable since one could expect the metabolic-rate of 100 cells to be more than one cell. Thus it is possible to have two people of the same weight and fat content, but one of them has a smaller total number of fat cells leading to a lower metabolic rate and greater resistance to slimming.

Good correlations were obtained for the relationship between weight loss and total energy expenditure by both methods. The correlation coefficients for the relationship between weight loss and the energy cost of walking and cycling were not significant, but sedentary subjects spend only a small proportion of their day in these pursuits. Fig. 3 shows that weight maintenance would be expected when the expenditure was 1500 kcal. per day (i.e., equal to the food intake). Those who failed to lose weight had low energy expenditures. There was a good correlation between the methods for measuring energy expenditure ($r=0{\cdot}7$) but the slopes of the lines in fig. 3 are clearly different. It is possible from these slopes to calculate the energy content per g. weight lost. Using the fat-balance method the slope corresponds to 10 kcal. per g., which is surely too high. Using the diary-card method the slope corresponds to 5 kcal. per g., which is probably too low. Since it is not possible to say which method is correct, we suggest that more comparisons are made of this sort.

We have established that resistance to slimming can be associated with a low metabolic-rate. This was most striking in women who had been slimming for a long time ($r=0{\cdot}55$) and in women of lower body-weight ($r=0{\cdot}43$) and with lower body fat ($r=0{\cdot}43$). Thus those with most fat to lose generally lost more weight. This is consistent with the view that some slimmers reach a plateau in their weight losses after a period of time. At this point their metabolic-rate has been depressed. Nevertheless, two-thirds of our women who were carefully selected because of an apparent plateau did lose weight and must come within our category of self-deluders.

We thank Dr J. S. Garrow, Dr J. V. G. A. Durnin, and Miss Jean Stuart for advice and assistance, and Dr Margaret Ashwell for the fat-biopsy analyses. We thank Slimming Magazine Ltd for the use of their slimming clubs, giving us access to women attending their hydro at Ragdale Hall, and for providing funds and personnel for this study: in particular we are grateful to Mrs D. Macadie on their staff for invaluable assistance.

Requests for reprints should be addressed to D. S. M.

REFERENCES

1. Keys, A., Brozck, J., Hershel, A., Mickelson, O., Taylor, H. L. The Biology of Human Starvation. Minnesota, 1950.
2. Martinaud, M., Trémolieres, J. *Nutr. Dieta.* 1964, **6**, 77.
3. Apfelbaum, M., Botsarron, J., Lacatis, D. *Am. J. clin. Nutr.* 1971, **24**, 1405.
4. Miller, D. S., Mumford, P. *ibid.* 1967, **20**, 1212.
5. Simms, E. A. H., Danforth, E., Horton, E. S., Bray, G. A., Glennon, J. A., Salaus, L. B. *Rec. Progr. Hormone Res.* 1973, **29**, 457.
6. Miller, D. S., Payne, P. R. *Br. J. Nutr.* 1959, **13**, 501.
7. Durnin, J. V. G. A., Rahman, M. M. *ibid.* 1967, **21**, 681.
8. Weir, J. B. V. *J. Physiol., Lond.* 1949, **109**, 1.
9. Stock, M. J., Acheson, K. *Proc. 2nd int. Congr. Energy Balance Man.* 1974.
10. Bray, G. A., Swartz, M., Rozin, R. R., Lister, H. *Metabolism,* 1970, **19**, 418.
11. Kleiber, M. *Physiol. Rev.* 1947, **27**, 511.

Preliminary Communications

METRONIDAZOLE FOR CROHN'S DISEASE

B. URSING C. KAMME

Departments of Infectious Diseases and Medical Microbiology, University Hospital, Lund, Sweden

Summary Five patients with Crohn's disease for 4 months to 12 years were treated with metronidazole. Four of them improved after 2–4 weeks' treatment. In three of them corticosteroids and sulphasalazine could be withdrawn. One patient did not improve until 4 months of metronidazole treatment had passed and corticosteroids were reintroduced. In three patients metronidazole was discontinued after 4–6 months of treatment. Two of them had no signs or symptoms of relapse 3 and 6 months later. The third patient is free from symptoms but laboratory data indicate disease activity.

INTRODUCTION

THE intestinal flora has been reported to be the same in patients with Crohn's disease and in healthy subjects.[1–4] However, overgrowth of microorganisms