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Aspects of Obesity

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Abstract

The topic of obesity could provide material for a series of symposia. Personal prejudice has largely determined the aspects chosen for discussion here, and these are intended to demonstrate features bearing on our understanding of the nature of this disorder, which, as is generally recognised, has such profound medical and social implications. Adiposity itself is less of a problem than the sequelae and complications which so commonly occur. The epidemiology of obesity will not be dealt with now, but a moment's reflection on the morbidity and mortality associated with being overweight will suffice to emphasise the importance of even a single example such as diabetes mellitus.

ASPECTS OF OBESITY

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The topic of obesity could provide material for a series of symposia. Personal prejudice has largely determined the aspects chosen for discussion here, and these are intended to demonstrate features bearing on our understanding of the nature of this disorder, which, as is generally recognised, has such profound medical and social implications. Adiposity itself is less of a problem than the sequelae and complications which so commonly occur. The epidemiology of obesity will not be dealt with now, but a moment's reflection on the morbidity and mortality associated with being overweight will suffice to emphasise the importance of even a single example such as diabetes mellitus.

In the studies to be discussed the necessity for a definition of obesity naturally arises, but this need not be laboured. Tables relating height and weight, sex and age, are readily available. These tables usually provide average weights based on height. It might be argued that an average body weight is less suitable than an ideal weight as a basis for investigation and for planning treatment. Tables of average weights are based on actuarial analysis of

previous experience, and these show a tendency for most people to put on weight with advancing years. Such a concept appears to condone an increase in weight that may indeed be harmful. At present it is impossible to assess the contribution made by coincident factors such as diminishing physical activity to the disabilities often attributed directly to obesity.

Other standards have been proposed from time to time to distinguish the normal from the obese, and these are usually based on measurements or estimates of the amount of obese tissue in the individual. Some of these techniques are as simple as measuring the thickness of skin folds with a calliper in standard areas, while others are based on the volume of distribution of deuterium oxide or tritiated water which will equilibrate with the total body water and from this the lean cell mass and thus by difference the amount of adipose tissue can be determined. Weighing under water will also provide an estimate of body fat. The choice between these and other methods is not critical, however, for the purpose of this paper. In studying obesity it is more profitable to select groups of individuals who clearly transgress the bounds of any normal range, so that by any standard they are clearly abnormal.

When confronted by an obese patient, and faced with the necessity of advising treatment, two immediate problems present themselves. Firstly, and as a matter of expediency, what advice should be offered? Secondly, why has the patient become obese? In seeking to rationalise the second question we may answer the first more effectively.

Fundamentally, it may be claimed, the fat are overweight because control of the balance between energy intake and output is defective, and the balance remains positive too often for too long. From this premise it may be argued reasonably that the loss of metabolic equilibrium could occur because the intake of energy was in excess of needs, or alternatively, and even in addition, that the output of energy was insufficient to deal with the load imposed on the intake side of the equation. These are really about the only assumptions that can safely be made at present.

The contribution of energy output as a mechanism for maintaining a steady weight is difficult to study because of the technical problems involved, and particularly because the investigation must be extended as far as possible in time in order to take account of fluctuations that are constantly occurring. Variations in the amount of energy lost in the urine and stools can be discarded as factors of importance in most cases. Variations in the physical activity of the patient however certainly cannot be ignored. Even when it has been shown that the obese exert themselves less than those who remain thin, the problem remains whether this economy of effort is cause or effect. Only prospective studies would provide an adequate answer to this question and such an undertaking may be well nigh impossible. Several workers, notably Stunkard, a psychiatrist in Philadelphia (Chirico and Stunkard, 1960) and Mayer (Johnson, Burke and Mayer, 1956) in the Department of Public Health in Boston, have shown that on average the obese exert themselves less than do their more slender controls. This applies in children as well as in adults, and appears to affect girls more than boys. It may be noted however that the fat patient does more work than the lean in moving the same distance, for the most obvious of reasons, namely that the bulk to be moved is greater.

Thus the conclusion stands that many fat people spend less energy on kinetics than those who are thin, and they apparently fail to restrict their energy intake appropriately, and therefore become or remain obese.

For 50 years or more, suggestions have been made that the normal individual has a metabolic "bypass" denied to the obese, for burning off surplus energy, and that for this reason the fat man who eats more than his energy output would require will accumulate adipose tissue, while the thin man with his "bypass" remains thin in spite of eating more than is necessary to meet his strict requirements. This postulated mechanism was described as "luxus konsumption" by Grafe (1933) but it has never really been demonstrated with conviction. Indeed more evidence has been adduced against it than in its favour.

Two further aspects of the output side of the energy equation should be mentioned here. The first of these is exemplified by a group of seven grossly obese patients who were studied most rigorously under hospital conditions, but in a general ward. Their diets provided between 370 and 550 kcal. daily only and by encouraging them to take exercise until they were walking as much as ten miles daily, these patients were able to dissipate sufficient energy to achieve negative energy balances to the extent of 2500-3000 kcal. daily. As might be predicted they all lost very substantial amounts of weight in periods of six weeks study, the

losses ranging between 13.4 and 17.3 kg. This of course represents rather an unusual state of affairs and would not normally be practicable or perhaps advisable except under strict supervision. Only the obese who remain mechanically intact are capable of this degree of activity, but it serves to show what can be achieved in this way.

The second aspect concerns the effect of exercise on appetite. The amount of exercise one takes will affect the debit side of the energy equation, while the appetite will be all important in determining the energy credit, assuming that free access to food is available. Mayer and his colleagues (1954) carried out experiments using rats in cages equipped with treadmills so that the animals were exercised daily for variable periods. With free access to food, over a wide range of energy expenditure, the animals matched their intake of calories against their energy output in such a way that they neither gained nor lost weight. Only at either extreme of physical activity did this nicely balanced mechanism show signs of breaking down; at one end because of exhaustion from overwork. At the other end, and infinitely more important for our understanding of obesity, when the animals' opportunities for exercise were restricted, their food consumption rose above their requirements, and as might be expected, their weight began to increase.

The implication is clear, namely that energy intake will match the output, provided the amount of physical exercise taken does not fall below a certain minimum.

Some of the other factors bearing on the rate and amount of weight loss occurring on reducing diets are illustrated by the case of Christine E. (Figs. 1 and 2). This patient was weighed daily for a period of some 17 months, while she was on a diet usually providing approximately 400 kcal. daily: occasional changes were made for special purposes. It may be added that in spite of the effort and expense involved in supervising her diet and activities while her weight was reduced to less than half her initial weight, she has since regained almost her original weight and has now become a diabetic. Before the end of the study, because of persistent suppuration, it became necessary to excise her umbilicus, and this was removed along with a layer of fat weighing approximately 12 lbs.

During the time covered by Fig. 1 her weight was reduced from 156 kg. (344 lbs. or 24½ stones) to 76 kg. (168 lbs. or 12 stones). Such a fall is equivalent to an average daily loss of
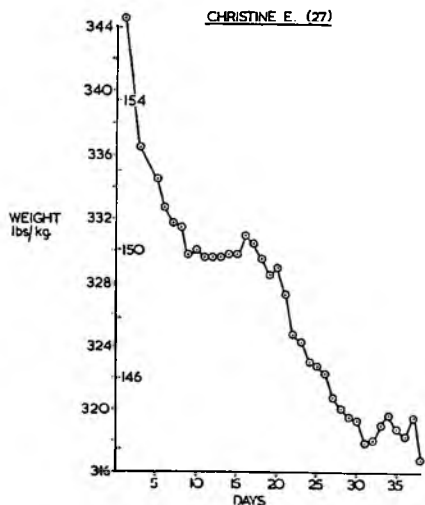
15.

Fig. I. Loss of weight by an obese patient on a diet providing 400 kcal daily.

Fig. 2 Daily weight changes in an obese patient during the first 5 weeks of a strict reducing regime.

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150 g. or 0.33 lb. Most of the points in Fig. 1 represent intervals of one week. It will be noted that the fall in weight tends to be step-wise, and indeed at one stage for a period lasting several weeks she failed to lose any weight at all, although adhering to the usual regimen. In spite of fluctuations of this type however, the overall loss of weight was steady throughout. For a phase of 8 months approximately, records were kept of her menstrual periods, and it will be seen again that about the time of onset of her period, a sharp rise in weight usually occurred, subsiding again thereafter with an appropriate increment in weight loss, to resume the steady decline.

In Fig. 2 the daily weight changes are shown that occurred in the interval following her admission to hospital. The striking alterations in the rate of loss of weight may easily be seen. From the point of view of obese patients taking strict reducing diets, it is most important that they should be told what they may anticipate when dieting conscientiously. Unless this is done they become disillusioned when the rapid initial loss of weight of the type illustrated in Fig. 2 fails to continue, and thereafter abandon the very real effort involved in adhering to a regimen likely to produce consistent results. Even more discouraging are the phases of water retention also illustrated, when not only is loss of weight not continuing but gains in weight are occurring, sometimes for several days in succession. Phases of this type may persist for 10-14 days or more, and unless the patient is constantly reminded that this failure to lose weight is temporary only, that it is relatively common and will be succeeded by a compensating period with an increased rate of weight loss, only the stupid or unnaturally stoical patient is likely to continue with dietary restrictions.

The mechanism responsible for the water retention accounting in turn for these rather anomalous changes in weight has not yet been identified.

Studies by Russell (1962) on sodium and water excretion by obese patients on reducing diets strongly suggest that the surplus water accumulated in the circumstances described is accompanied by sufficient sodium to keep the additional water retained isotonic with extracellular fluid: from time to time the excess of both is released and excreted. There are grounds for suggesting that something similar may happen when more generous diets providing up to 1000 kcal. daily are in use. In these circumstances, feeding a high carbo-hydrate diet enhances water retention, a high fat intake on the other hand will promote a more rapid rate of loss of weight for a few days, until a new equilibrium has been established, and weight loss will then continue predictably, depending on the energy balance.

Studies undertaken in a number of centres bearing on the weight reducing properties of a variety of diets would indicate that when adhered to strictly, and excluding short term differences due to variations in water balance, the ultimate rate of loss of weight depends upon the caloric content of the diet, and not upon the form in which these calories are taken.

It should be added that while the energy content of food is all important in maintaining weight at a constant level, the relative content of carbohydrate, protein and fat in the food eaten are probably of minor importance except to the extent that they affect the palatability of food and therefore the appetite of the patient. In the longer term, however, the reverse would be true when the patient or subject has freedom of access to food. The satiety value or appetite suppressing properties of food must be of the greatest importance in determining when a person with free access to food will stop eating. Our ignorance in this regard must largely be attributable to the formidable problem of demonstrating in man what it is that stops him eating. We know that in animals hypothalamic centres for eating and for satiety can be demonstrated, and that exercise and temperature, solitary confinement or group feeding, restricted periods of feeding or continuous access to food can all affect the issue quite profoundly.

The heat conserving properties of a layer of subcutaneous fat and the effect on body temperature was studied recently by Quaade (1963) in Copenhagen. He measured the skin temperature on the surface and the temperature deep to the abdominal layer of fat in groups of obese, normal and thin individuals, and showed that although the abdominal temperature in the fat man is slightly higher than in the thin, the skin temperature is lower in the fat. There are several possible explanations for these differences, but one reasonable interpretation would be that a heavier layer of surface fat is a more effective insulation against heat loss than a lighter covering of this type. Such a factor might contribute to the difficulty some patients evidently have in dissipating surplus energy.

There are relatively few studies available of protein metabolism in the obese and such as there are indicate that it may be normal. This conclusion, however, should be accepted with reserve for the present. Our own investigations suggest that obese patients lose little protein when taking severely restricted diets.

The obese also show an unusual resistance to the development of ketosis: unusual in the sense that under dietary conditions and conditions of exercise, where the lean can be expected to excrete relatively large quantities of ketone bodies, the obese fail to do so. This too is characteristic of the maturity onset insulin resistant adult diabetic who is usually obese, but the protective factor possibly common to these two important conditions and responsible for their relative immunity to ketosis remains to be shown.

One popular form of practical therapeutics for the control of obesity is the use of so-called appetite suppressants. In a society with access to unlimited quantities of food, the problem for many is when to stop eating. The clinical response to dietary restrictions is disappointing indeed, and there is a pressing need for some method of controlling appetite that does not depend only on the patient's ability to exercise restraint at the table. The commercial possibilities for appetite suppressive drugs have not been wasted on the manufacturers, and there are now 25 or more such preparations available in this country. Most of these drugs are ephedrine derivatives. Some years ago my colleagues and I attempted to assess the value of two of these drugs in the management of obesity (Hampson et al., 1960). Dexamphetamine is widely used for this and other purposes, and it seemed a useful standard for comparison with a further drug on behalf of which at that time strong claims were being made for its efficacy as an appetite suppressant, namely phenmetrazine. Both were compared against an inert placebo made of chalk.

This clinical trial was arranged with out-patients attending for dietary advice and they were all prescribed diets of approximately 1000 kcal. daily. They were seen at intervals of one week, and were given each treatment in turn for 3 periods each of 6 successive weeks duration, making 18 weeks in all. The order of administration of the 3 drugs was randomised, so as to eliminate as far as possible bias in favour of or against a regime because it came earlier or later in the period of study. Analysis showed that both the drugs were somewhat more effective than the control tab-

lets, but that when the results were rearranged and compared, irrespective of the drug but rather between the order of the 3 periods of treatment, much more was achieved in terms of weight reduction in the first period of 6 weeks, than in either of the two succeeding.

From this has emerged the view that this group of drugs may have some little help to offer, but only as a temporary expedient. It is widely recognised that they must be regarded as drugs of addiction, and indeed our psychiatrist colleagues as well as others would be glad to see their use in the treatment of obesity restricted or abolished altogether. Anorectic drugs are never a substitute for the discipline of dieting, and the marginal benefits they have to offer seldom justify their use.

Practising doctors are constantly preoccupied with the necessity for weight reduction and the difficulties surrounding this process. Prophylaxis is the essence of good treatment, and this applies to overnutrition just as it does to so many other disorders. Although so much attention has been paid to the process of reducing weight, very little has been done to study the mechanism of gaining weight in the obese. Several years ago Dr. Passmore and his colleagues (1955) carried out energy balance studies on a group of thin young men who were overfed to capacity for a relatively brief period. In 1962 we (Passmore, Strong, Swindells and el Din, 1963) did the same for a pair of overweight young women who after a period of equilibration ate as much food as they could tolerate. In the course of 9 days overfeeding, largely with carbohydrate, they gained almost 3 kg. in weight, but in 6 days afterwards of almost complete starvation, they not only lost the 3 kg. gained, but also almost 3 kg. further as well.

When the findings in the fat young women were compared with the thin young men, remarkable differences were seen. These studies suggest that there is some substance in the frequent complaints of the obese about what they regard as a form of biological injustice and what is sceptically disregarded by their physicians, namely that when taking the same amount of food as their thinner fellows, they gain weight, while the lean remain so. For a given excess of calories, the fat girls gained weight much more dramatically than the thin men, and indeed for comparable gains of weight, the excess of calories required by the thin men was more than twice that for the girls. For a gain of 2.5 kg. in weight, 20,000

kcal. each was needed by the thin men, as compared with 10,000 and 6,500 respectively by the two fat girls.

This procedure of comparing the fat with the lean has led to studies in other aspects of metabolism as well, including steroid hormone metabolism. In recent years many reports have appeared, mainly concerned with adreno-cortical function, and usually showing that the excretion of 17-hydroxycorticosteroids was greater in the fat than in the lean. Analysis of this data commonly indicates that the higher findings recorded are associated with, and possibly accounted for, by the greater bulk of the obese patient. There is no doubt that some fat people go through a phase when their adrenocortical function is so vigorous as to create serious doubts regarding their clinical status, in the sense that they may be regarded as suffering from Cushing's syndrome.

Our own studies on this aspect of obesity were concerned with oestrogen metabolism in a group of postmenopausal patients who ranged from the extremes of being underweight to overweight (Brown and Strong, 1965). Injections of oestradiol were given, that is one of the precursors of all the oestrogen metabolites to be found in the urine. The methods of assay available at the time made it possible to study the recovery of the administered material in the form of two of the major metabolites, namely oestriol and oestrone. It was found that the heavier the individual, the greater was the recovery of administered oestrogen as as oestriol, and the less as oestrone. This has interesting potential repercussions, since the biological activity of these oestrogen metabolites varies very widely, and some of the metabolic and other abnormalities to be found in the obese might be due to factors of this type.

One further aspect of our eating habits should be mentioned. Stunkard has described what he calls the "night-eating syndrome", implying that this group of obese patients eats little during the day, but in the evening and at night consumes large quantities of food. This perhaps is an extreme example of a common habit of eating little or nothing of energy value at breakfast or lunch, but then taking a large evening meal.

Hollifield and Parson (1962) have studied a comparable regimen in rats. One of two similar groups of rats was allowed free access to food at all times, while the other group was allowed to feed for two hours daily only. After a brief period when the "2 hour feeders" lost some weight, they rapidly caught up with and overtook their controls who had free and constant access to food, as is usual with laboratory rats. The different rates of gain in weight were not accounted for by differences in food intake, and other studies of fat metabolism were thought to provide a tentative explanation. So far as is known the activity of the animals was not controlled, and one possibility would seem to be that the "2 hour feeders" soon learned when it would be to their advantage to hunt for food, and that for the rest of their time they conserved their energy in rest or sleep.

Studies of the metabolism of labelled acetate by these animals showed that the "2 hour feeders" in the course of seven days increased enormously their capacity to store the acetate as adipose tissue. The suggestion is therefore that adaptation to this unusual type of feeding regimen radically altered the metabolism of the animals, so that they developed what may be described as a "storage phase" of fat metabolism.

These and many other metabolic differences that are emerging to distinguish the fat from the lean offer the prospect that out of these investigations may arise better methods of managing disordered weight control and so reduce an important source of morbidity and mortality in the better fed countries of the world.

The wonder of it is perhaps not so much that some become obese, but rather that this fate overtakes so relatively few.

REFERENCES

Brown, J. B. and Strong, J. A. (1965) J. Endocrin. in press.

Chirico, A. M. and Stunkard, A. J. (1960), New Eng. J. Med., 263, 935-940.

Grafe, E. (1933). Metabolic diseases and their treatment. Philadelphia: Lea & Febiger, quoted by Passmore et al. (1955).

Hampson, J., Loraine, J. A. and Strong, J. A. (1960). Lancet, i, 1265-1267.

Hollifield, G. and Parson, W. (1962). J. clin. Invest. 41, 245-253.

Johnson, M. L., Burke, B .S. and Mayer, J. (1956). Amer. J. Clin. Nutrition, 4, 37-44.

Mayer, J., Marshall, N.B., Vitale, J. J., Christensen, J. H., Mashayekhi, M. B., and Stare, F. J. (1954). Amer. J. Physiol. 177, 544-548.

Passmore, R., Meiklejohn, A. P., Dewar, A. D. and Thow, R. K. (1955). Brit. J. Nutrit., 9, 20-27.

Passmore, R., Strong, J. A., Swindells, Y. E. and el Din, N. (1963). Brit. J. Nutrit., 17, 373-383.

Quaade, F. (1963). Lancet, ii, 429-432.

Russell, G. F. M. (1962). Clin. Sci. 22, 269-277.