STUDIES IN NORMAL AND OBESE SUBJECTS WITH A MONITORED FOOD DISPENSING DEVICE*

Sami A. Hashim† and Theodore B. Van Itallie
Department of Medicine, St. Luke's Hospital, and the Institute of Nutrition Sciences, Columbia University, New York, N.Y.

The study of food intake in man is fraught with difficulties which result from the enormously complex nature of human eating behavior. In man, in contrast to lower animals, the eating process involves an intricate mixture of physiologic, psychologic, cultural and esthetic considerations. People eat not only to assuage hunger, but because of the enjoyment of the meal ceremony, the pleasures of the palate and often to gratify unconscious needs that are hard to identify. Because of inherent difficulties in studying human food intake in the usual setting, we have attempted to develop a system that would minimize the variables involved and thereby improve the chances of obtaining more reliable and reproducible data.

Procedure

The system is one based in part on technics used by physiologists, pharmacologists and experimental psychologists to study feeding behavior in experimental animals.[1-4] In most of these studies use has been made of the so-called Skinner box in which a rat can obtain a pellet of food by pressing a lever. The pellet is delivered to the rat by an electronically monitored mechanism. Lever-pressing activity is graphed cumulatively by a chart-recorder which responds to the signal made when the lever is moved. In this way, detailed and accurate information concerning rate of food ingestion, size of meals and intervals between feedings can be obtained.

The feeding machine described in an earlier report[5] and used in the present studies is shown in FIGURE 1. It consists of a reservoir containing a liquid formula diet. The formula mixture is constantly mixed by a magnetic stirrer. Tubing from the reservoir leads to a dispensing syringe-type pump which delivers a predetermined volume of formula through the mouthpiece. The pump is set to respond with a single delivery cycle to the signal of an activating button. Thus, whenever the button is pressed, 7.4 ml. of formula are delivered directly into the mouth of the subject by the punp. Each delivery is recorded by the printing timer, shown on the top of the refrigerator which houses the delivery system. The timer prints out each event and the time and date at which the event occurred. The timer normally is left in a room remote from the subject who is kept unaware of its existence. When the system is in use by

*Supported in part by a grant from the National Institutes of Health (AM-08107).
†Career Development Investigator, National Heart Institute.

FIGURE 1. Food dispensing apparatus consisting of a refrigerated reservoir of formula diet constantly mixed by a magnetic stirrer. The syringe-pump delivers a predetermined volume of formula directly into the mouth of the subject upon activation of a button-switch. Each delivery is recorded on tape by a printing timer seen on top of refrigerator. (In actual use the reservoir, pump mechanism and recording device are concealed from the subject.)

an experimental subject the reservoir is covered. Thus, the subject can monitor the quantity consumed only by counting the number of mouthfuls of formula obtained. The data obtained from the tape can be converted into a cumulative graph with calories plotted against time. Alternatively, a cumulative chart recorder could be used to obtain a direct cumulative record of food intake.

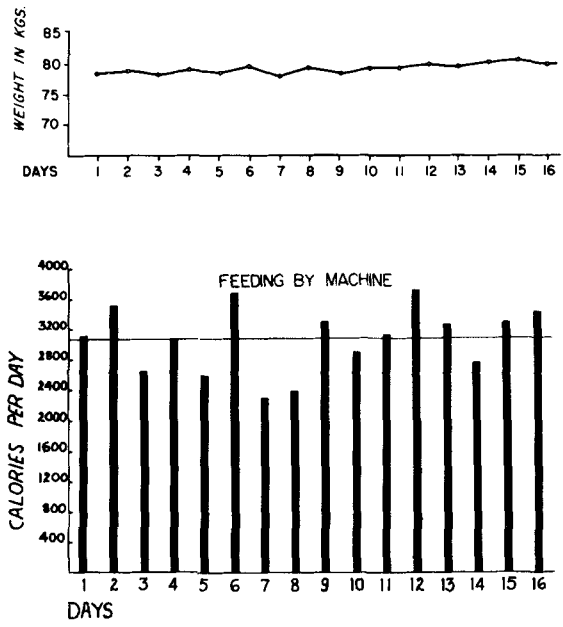

FIGURE 2. Spontaneous calorie intake (vertical bars) of a 60 year-old normal weight subject fed by machine. Body weight was maintained over a sixteen-day period. (Horizontal line represents mean daily calorie intake.)

In the formula diet* used in these studies, carbohydrate contributed 50 per cent of the calories, protein 20 per cent and fat 30 per cent. The formula contained vitamins and minerals in amounts adequate for daily maintenance.

Results

The first normal-weight subject studied was well suited to the feeding machine because a severe deformity of his mouth made ingestion of normal food difficult. This patient quickly adapted to the feeding machine, maintaining his body weight at a fairly constant level during the 16-day experimental

*Provided as "Nutrament" through the courtesy of Warren M. Cox, Mead Johnson Research Laboratories, Evansville, Ind.

period (FIGURE 2). His daily calorie intake did not vary appreciably, averaging 3075 ± 438 (S.D.) calories per day. Although he was instructed to consume formula ad libitum, the subject maintained a three-meal-per-day intake pattern.

A healthy 20 year-old volunteer subject also readily maintained his body weight during a nine-day period on the machine consuming an average of 4430 calories per day (FIGURE 3). In this case the machine was available to the sub-

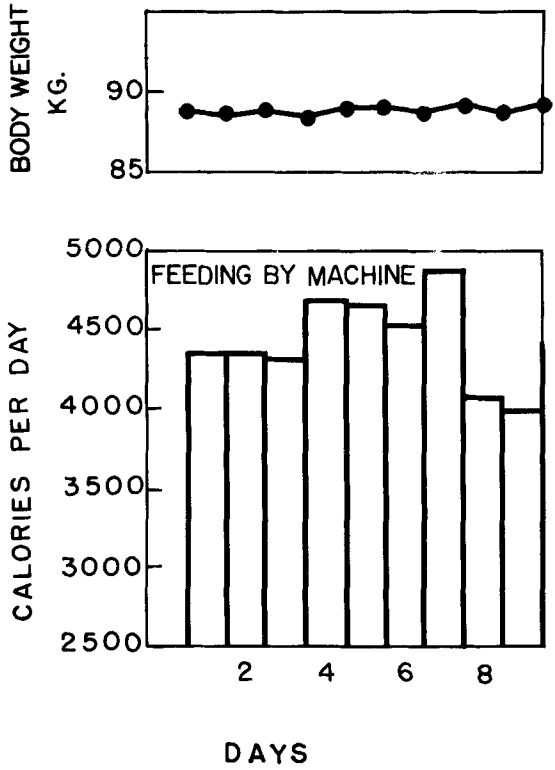

FIGURE 3. Spontaneous calorie intake of a 20 year-old normal weight volunteer subject obtaining liquid formula diet by machine. Body weight was maintained over a nine-day period.

ject three times daily at hours corresponding to the usual breakfast, luncheon and dinner. The subject remained physically active throughout this period.

Studies were made of the responses of grossly obese subjects to machine feeding. The results obtained in one individual, a 27-year-old man, are shown in FIGURE 4. Initially, he weighed 400 pounds. On the feeding machine this subject did not consume enough calories to maintain weight. Although he was asked to obtain food from the machine whenever hungry, he took only an

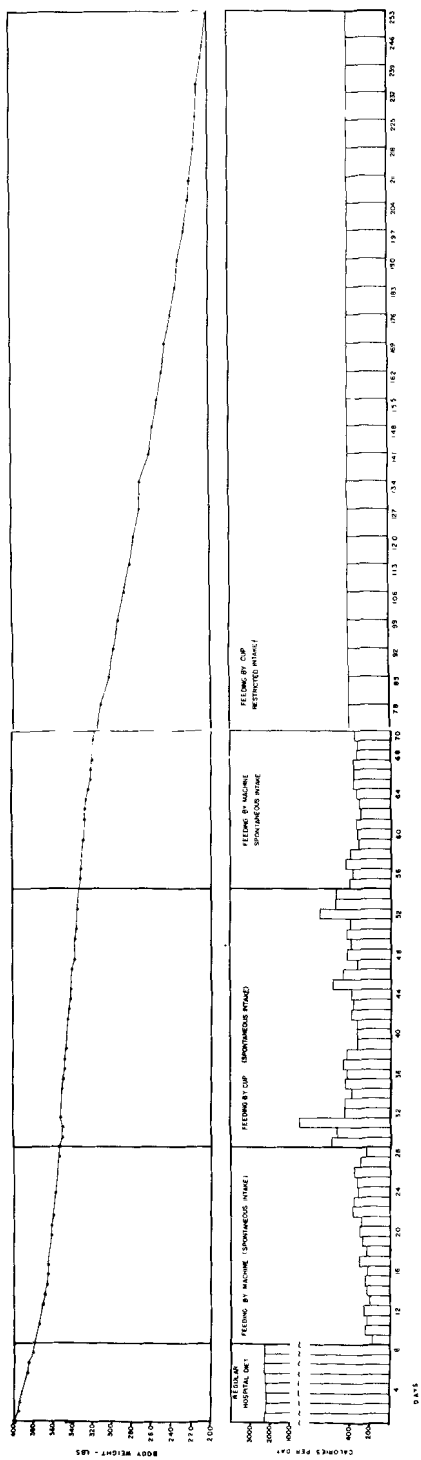

FIGURE 4. Daily calorie intake of a 27 year-old obese subject ingesting formula diet spontaneously by machine and by cup. Note the diminution in food intake by machine as compared to the intake of the same formula diet by cup. After 70 days of spontaneous intake, the formula intake was restricted to 400 calories per day. The total weight loss was 200 lbs. over an eight-month period.

average of 275 ± 57 calories per day for a period of 18 days. The machine was at his bedside and he remained on the metabolic ward throughout. To determine whether the bizarre feeding situation was by itself inhibiting his food intake, he was asked (after 18 days on the machine) to feed himself the same formula ad libitum using a pitcher and cup. In the third section of FIGURE 4 it can be seen that his calorie intake increased on this program to about 500 per day. He was returned to machine feeding after another 26 days and, again, spontaneous food intake dropped to a lower level. During all this time weight was steadily lost and the patient never complained of hunger or gastrointestinal discomfort. Ketonuria was always present and the blood ketone level on several occasions was 15 mg. per 100 ml.

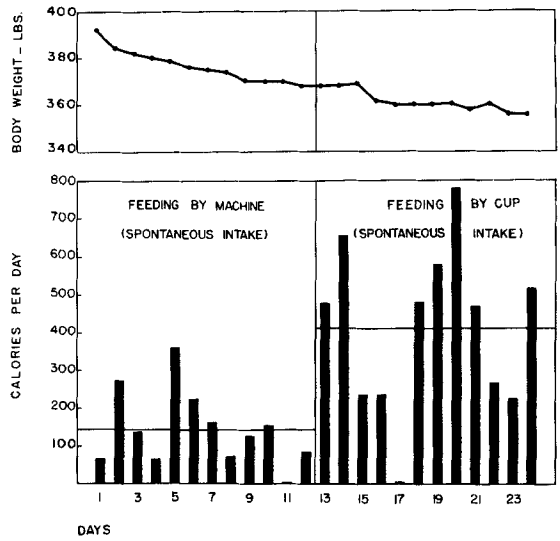

FIGURE 5. Spontaneous food intake of a markedly obese 36 year-old woman obtaining liquid formula diet by machine and by cup. The mean daily calorie intake *(horizontal line)* by machine was one-third that obtained by cup.

Subsequently, the subject went home on a 400 calorie per day formula regimen with instructions to restrict physical activity. He was followed on a weekly basis in the metabolic clinic. After 252 days of calorie restriction the subject had achieved a 200 pound weight loss.

The response to feeding by machine of another obese subject, a woman aged 36, is shown in FIGURE 5. Her spontaneous food intake over a 12-day period of observation also was extraordinarily low, 144 ± 91 calories per day. During this time she lost 23 pounds. When she took the same formula by cup, calorie intake increased to 442 ± 190. Three additional obese subjects showed a similar inhibition of calorie intake when fed by machine.

Discussion

The feeding system described attempts to reduce the eating process to its simplest components. The diet is a bland liquid formula and the manner of obtaining it is devoid of all "sociability." The device is designed to prevent the subject from estimating, except by the number of mouthfuls of liquid swallowed, how much food he consumes per day. In other words, he is guided principally by subjective hunger. The results printed on the electronic recorder are not available to him and he is not aware that his intake is being recorded.

The data show that the five obese subjects ate only a small fraction of their daily calorie requirements by machine. This low spontaneous intake was maintained as long as machine feeding was continued. When the obese subjects were permitted to drink the formula by cup, they immediately consumed more; nevertheless, their daily calorie intake did not exceed 25 per cent of their calculated calorie needs.

In contrast to the obese patients, the two lean subjects took enough formula by machine to maintain body weight. It must be emphasized that more subjects must be studied to confirm the apparent difference in response to the machine feeding situation of lean and grossly obese individuals. Nevertheless, these preliminary studies cast doubt on the concept that some metabolic or physiologic derangement drives obese persons to overeat and then to maintain their obesity. To the contrary, for reasons yet to be explained, obese persons display a remarkable decrease in food intake and lose weight rapidly when they are put into the rudimentary eating situation provided by the feeding machine.

It is tempting to infer from these results that the problem the obese person has with his diet may relate to the setting in which he eats and the meaning food has come to assume for him aside from its use as a fuel. In the acute treatment of severe obesity consideration might well be given to the possible value of stripping the eating process of its trappings and reducing it to the rudimentary level of satisfying physiologic hunger. Of course, under such circumstances, when the patient returns to his usual environment, the lost weight presumably will be regained unless his attitudes toward food and its role in his life have been altered.

Summary

The feasibility of studying eating behavior in human subjects by the use of an electronically monitored food dispensing system is reported. Availability of a homogeneous nutritionally adequate formula emulsion makes it possible to reduce the diet to its simplest components and dissociate it from most of the metering cues that familiar foods provide. Thus, in the feeding machine situation, subjects are more likely to eat only in response to physiologic hunger and find it difficult, if not impossible, to monitor their intake from their experience with normal food.

Normal-weight subjects appear able to maintain their weight while being fed by machine. In studies to date, such individuals exhibit a three-meal-per-day pattern of intake. Whether a larger series would consistently show a similar pattern and whether certain cues such as awareness of the time of day play an important role in maintaining the three-meal pattern remains to be determined.

In preliminary studies grossly obese subjects show a surprising reduction of food intake when they are fed by machine. This is in apparent contrast to the behavior of the normal weight individuals. More subjects, lean and obese, must be studied before this difference in response to the feeding machine situation can be considered established.

Whether the inhibition of food intake exhibited by obese patients represents a physiologic effect of massive stores of fat, or whether it results from psychologic factors relating to guilt about the obesity, fear of the feeding device, inability to adjust to the formula, or some other cause, is unknown. The fact that such a striking difference does seem to be present merits further investigation.

References

1. SKINNER, B. F. 1938. The Behavior of Organisms. Appleton-Century. New York, N. Y.
2. ANLIKER, J. & J. MAYER. 1956. An operant conditioning technique for studying feeding-fasting patterns in normal and obese mice. J. Appl. Physiol. **8:** 667.
3. MILLER, N. E. 1955. Shortcomings of food consumption as a measure of hunger; results from other behavioral techniques. Ann. N. Y. Acad. Sci. **63:** 141.
4. TEITELBAUM, P. 1957. Random and food-directed activity in hyperphagic and normal rats. J. Comp. Physiol. Psychol. **51:** 135.
5. HASHIM, S. A. & T. B. VAN ITALLIE. 1964. An automatically monitored food dispensing apparatus for the study of food intake in man. Fed. Proc. **23:** (Part 1, No. 1): 82.