THE UNIVERSITY OF MANITOBA

THE RELATIONSHIP OF PHYSICAL FITNESS, CALORIC INTAKE AND BODY FAT OF ADULTS WHO ATTENDED MANITOBA RENU CLINICS IN THE SUMMER OF 1973

By

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During the summer of 1973, a total of 898 adults from nine rural Manitoba towns volunteered to participate in a recreation-nutrition project entitled RENU. An assessment was made of their physical fitness, dietary intake and body fat. The percentage of fat in total body weight of 839 of the adults was calculated from skinfold measurements and compared with the RENU standards of "ideal" body composition. Obesity was found to be prevalent as 52.5% of the males and 82.8% of the females were above the "ideal" of 15 ± 3% and 20 ± 3% body fat respectively. Only the 419 subjects who had indicated a typical dietary intake and who had maintained a constant weight during the past two months were considered further in the present study. As calculated from their twenty-four-hour dietary recalls, the obese had lower caloric intakes than the non-obese. Further, the obese, relative to the non-obese, do not appear to have an excessive caloric intake; however, their caloric intake may be excessive relative to their energy expenditure. Physical activity was not measured directly, but was assumed to be represented by the level of physical fitness. Using the measure of the maximum oxygen uptake calculated from performance on a bicycle ergometer as compared to the "ideal" values used by RENU, the obese were judged less fit than the non-obese. Since the participants were studied in the static phase of obesity, their present patterns of eating and exercise may be a consequence of obesity rather than the reason for its development. This study also demonstrated the need to develop suitable techniques to assess physical activity in order to determine its relative importance in the etiology of obesity.

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INTRODUCTION

The prevalence of obesity among Canadians is evident from an examination of the results of Nutrition Canada, the national nutritional survey completed in 1972 (Nutrition Canada, 1973). Two factors typical of contemporary lifestyle which may account for this obesity are the availability of a wide variety of foods, many of them relatively high in caloric value and the reduction in the need for physical exertion. Frequent consumption of food and drink is encouraged by advertisements in all forms of the mass media. At the same time, there has been a decrease in physical activity due to the increased use of labor-saving devices (Bradfield, 1971). However, the degree to which overeating and/or underactivity contribute to the problem of obesity has yet to be measured.

Confusion arises in terminology used to define the state of obesity as "obesity" and "overweight" are often used interchangeably. Being obese means one's fat accumulation makes up a greater than normal fraction of the total body weight, whereas being overweight means one weighs more than the average according to tables of ideal weight (Deutch, 1974). The most widely used tables are those developed by the Metropolitan Life Insurance Company in which the "ideal" weight is estimated for various heights and according to the

size of body frame. An individual is considered overweight if his weight is greater than 10 percent above the ideal weight.

There are difficulties in using these tables of "ideal weights" as indicators of obesity. The tables do not include any standards to categorize each individual as to body frame, the choice being made at the individual's own discretion. Further (in using weight), there is no consideration given to the proportion of the components which make up the total body weight. Certainly an athlete with well-developed muscles would weigh more than a sedentary office worker of the same height and bone structure because of the higher proportion of muscle which weighs more than fat. Thus the athlete may be "overweight" according to the tables, yet not have an excess accumulation of fat.

For these reasons the measurement of subcutaneous fat is a more accurate indicator of the state of obesity. The percentage of total body weight composed of fat may be estimated by use of anthropometric or skinfold measurements. An individual is considered obese if the percentage of body fat is greater than 18 and 23 percent for males and females, respectively. Within or below the "ideal" range of 15 ± 3 percent for males and 20 ± 3 percent for females, the individuals are considered non-obese (RENU, 1974).

Since it is easy to measure weight but difficult to quantify fatness, most of the epidemiological data on the

subject of obesity is derived from studies of the overweight individual. Most individuals are overweight due to excess fat, with the exception of the athletic individual, whose excess weight results from the high proportion of muscle in relation to fat. Therefore the data from these studies is valid in a study of the obese as an excess in weight of the non-athletic individual most likely reflects an excess of fat (Bray, 1970).

In the Nutrition Canada Survey, the percentage of obese adults was calculated on the basis of the ponderal index[1] (Seltzer, 1966). The results of this study show that approximately 42 percent of adults 20-39 years of age were obese. In middle age (40-64 years) there was found to be a greater number of obese individuals as 61.4 percent of the males and 65 percent of females were obese. For those over the age of 65 years, the study reports that 65.8 and 79.9 percent of males and females respectively were obese (Nutrition Canada, 1973).

Obesity is a serious health problem because of the increased mortality and morbidity associated with the disease. In the National Diet Heart Study obese subjects were more prone to angina pectoris and to sudden death than were people

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[1]The ponderal index is the ratio of the height in inches to the cube root of weight in pounds. Below 12.5 is considered a high risk, an indicator of excess body weight, whereas 12.5 and above is considered low risk, an indicator of leanness.

of normal weight (Kannel et al., 1967). Obesity is associated with increased liability to death by a variety of degenerative diseases. A study by the Metropolitan Life Insurance Company showed a 31 percent increase in mortality attributed to degenerative disease if the subject's weight exceeded 20 percent of the "ideal" (Davies et al., 1963). The obese also suffer increased metabolic disorders, that is gallstones and diabetes mellitus (Bray, 1970) and simple mechanical disorders such as backache, flat feet, arthritis, varicose veins, hernia and bronchitis (Durnin, 1971). The incidence of obesity imposes a threat to the health of the nation and hence there is reason for concern as to the underlying causes.

Obesity may be considered an "energy crisis" as it results from an excess accumulation of fat which is the most important form of energy storage. For the normal individual an energy balance exists in which the energy provided by ingested foods equals energy output for metabolic work and physical activity. The "crisis" occurs when the caloric value of ingested food is greater than daily requirements, the excess calories being converted to fatty acids and stored in adipose tissue cells. Such an upset in the energy balance may occur by increasing intake while maintaining output or by decreasing output while maintaining intake. Thus obesity may develop in persons continuing normal food intake if energy expenditure is reduced or by increasing food consumption

while normal activity is maintained.

The control of food intake in the regulation of body energy balance has been the concern of many nutritionists, physiologists, psychologists and behaviorists and yet a complete understanding of the control mechanisms is still lacking. In a recent symposium, Baumgardt (1974) summarized the components which affect feeding behavior as: presence and palatability of food, degree of nutrition depletion, chemical and physical conditions in the gut, behavioral interaction with other members of the group and presence or absence of inhibitory factors such as environmental temperature, noise, and disturbance. Evidently, the amount of food consumed indicates a complex interrelationship with the stimuli for food intake which, over time, relate to homeostasis of energy balance in normal individuals. The malfunction of one or more of these control mechanisms would result in an excess intake of calories and accumulation of body fat.

Aside from an upset in food intake, a decrease in energy expenditure would also result in a disruption of the energy balance. The increased use of labor-saving devices has led to a lowered requirement for physical exertion on the job (Bradfield, 1971). Leisure time has become an important potential source of physical activity to compensate for a decrease in the need for physical activity at work.

On the basis of a number of studies presented at a

conference on leisure in 1968, Laplante (1969) judges television as the most popular leisure activity, with spectator activities on the increase especially after the age of 35. With decreasing physical exertion necessary in all modes of life, modern man may be "homo sedentarius" as Durnin (1967) so fittingly commented.

Accordingly, the new lifestyle includes easy access to high calorie foods as well as little need for physical exercise which is required to balance the relatively excessive caloric intake. The object of the following study is to determine which of the two factors, excessive caloric intake or physical inactivity, or a combination, is responsible for the prevalence of obesity.

A recreation nutrition project entitled "RENU" was carried out in nine rural towns in Manitoba in the summer of 1973. The 1,250 subjects, 898 of which were adults, participated in physical fitness tests and a twenty-four-hour dietary recall followed by counselling on the basis of the results from these tests.

The caloric intake was obtained from the dietary data collected on the study. The physical fitness was assessed by an estimation of the maximum oxygen uptake (MVO_2), calculated from the performance on a bicycle ergometer. On the basis of percentage body fat, as estimated by skinfold measurements, the subjects were categorized as obese or non-obese. A difference in physical fitness and caloric intake of the

obese and non-obese would implicate the relative importance of these factors on energy balance and the cause and persistence of obesity.

REVIEW OF LITERATURE

The maintenance of homeostasis in body weight is dependent on the energy balance which exists when energy expenditure and caloric intake are equilibrated. Even though almost a ton of food may be consumed in one year, the normal individual shows little variation in body weight (Durnin, 1967). This precision does not occur on a daily basis as normal individuals show a marked variation in daily food intake which balances energy expenditure over the period of a week so that their body weight remains relatively constant (Durnin, 1967, Curtis and Bradfield, 1971).

Since the laws of physics describing the conservation of energy are operative in the living organism, it follows that an imbalance in energy intake and output will result in a gain or loss of body mass. Lean body mass and depot fat are in a dynamic state of equilibrium which relatively rapidly and significantly reflect changes in energy output and caloric intake (Parizkova, 1963). With an upset in the energy balance, either by an increase in intake or a decrease in output, the excess calories are stored as fat which, when accumulated, result in obesity.

From this knowledge the most obvious conclusion is that obesity is the result of excessive caloric intake and indeed the obese have acquired the stereotype of a glutton.

The common plea by the obese that "I eat like a bird" is often met with skepticism by doctors and nutritionists who consider only an excessive energy intake as the cause of obesity. However, this once popular idea is not supported by the literature since the obese may consume the same or less calories than the non-obese, as the following studies indicate.

Hutson et al. (1965) conducted a study of food intake and physical activity in relation to body composition of 515 healthy adults ages 25-44. From a twenty-four-hour recall the nutrient intake and physical activity were obtained. Based on estimations of percentage body fat as determined by laboratory methods and skinfold measurements, the subjects were divided into three categories of body fatness. The typical caloric intake as determined from the twenty-four-hour recall was compared with this data on body composition. The subjects with the highest percentage body weight as fat (above 30 percent for men and above 35 percent for women) consumed less calories per kilogram body weight than those with moderate or low percentages of body weight as fat. The mean caloric intake decreased with increasing degrees of body fatness, which implies that the obese do consume less calories than the non-obese.

In a comparison of food intake of sixty-three obese Trinidadian women with twenty-six normal weight controls, McCarthy (1966) found that the mean caloric intake among

obese women was not higher than that of controls. Similar observations were made by Maxfield and Konishi (1966) using a seven-day food record in a comparison of the daily patterns of eating of twenty-five obese (15 percent above ideal weight) and twenty-five non-obese women paired according to age. The difference in mean caloric intake between the non-obese and obese was not significant.

In a recent study by Lincoln (1972), the average caloric intake of eight hundred and sixty-seven men was determined according to results of a self-administered questionnaire which had originally been designed for a survey on cigarette smoking. The participants were categorized as obese or non-obese according to their ponderal indices. He found there was no significant difference in mean caloric intake between the obese and non-obese. Because the questionnaire was completed by each subject and mailed in, there are limitations on randomness and accuracy of the survey.

Probably the data which most accurately reflects the typical nutrient intakes of adults may be obtained from reports of Nutrition Canada, a national dietary survey completed in 1972. The subjects were described as high and low risk categories using the ponderal index: below 12 being high risk, obese and at or above 12 being low risk, non-obese. When compared with the median caloric intake as determined by the twenty-four-hour dietary recalls, the high risk category consumed the same or

less calories than the low risk in all age and sex classifications (Nutrition Canada, 1973).

Since there appears to be little difference in caloric intake in the obese and non-obese, a deficit of energy output logically remains as a prime factor in the etiology of obesity. The most significant factors which contribute to energy expenditure are basal metabolic rate (BMR), specific dynamic action (SDA) and physical activity (Pike and Brown, 1967).

Even though there are individual variations in the BMR and SDA, these factors do not account significantly for differences in energy requirements. As total resting energy output including SDA in any one individual is relatively fixed, the factor that most alters the total energy expenditure is physical activity (FAO/WHO, 1974, Durnin, 1971).

The importance of physical activity in the maintenance of energy balance has often been ignored by that portion of the lay population most concerned with energy balance, that is the prospective weight reducer. With the wide variety of reducing diets which encourage only a reduction in caloric intake, little attention has been given to the value of altering energy output to attain weight loss. Consequently, there have developed two common erroneous ideas regarding the effects of exercise, these have been summarized by Mayer (1968) as follows: (1) "Exercise requires little caloric expenditure, and (2) at any level of intake an increase in physical

activity is automatically followed by an increase in appetite and therefore self-defeating as a weight control measure."

The first idea that exercise requires little caloric expenditure may have arisen from the inexperienced use of charts indicating the number of kilocalories (calories) of energy expended in a specific activity. For example, vigorous bicycling expends 7.2 calories/kilogram/hour (Konishi, 1965). Since 3,500 calories is equivalent to one pound of fat, the average 150-pound (approximately 68.2 kg) man would require seven hours of vigorous bicycling to lose one pound of weight. The despondent obese may visualize any given performance as being accomplished in a single uninterrupted stretch and thus fail to recognize the cumulative effects of exercise. One half hour of bicycling every day would result in the loss of one pound of weight in two weeks or about twenty-six pounds a year, certainly a worthwhile contribution to a weight reducing regime.

Regarding the second idea of the effect on the appetite of increasing levels of activity, Jean Mayer has directed much of the research in both human and animal studies. It seems logical that an increase in activity would result in an increase in appetite and therefore caloric intake to maintain the energy balance. However, based on his research, Mayer postulates that the mechanism for control of appetite is inoperative if the subject is inactive to begin with.

A study conducted by Mayer and Thomas reported in 1967 included a measure of the food intake of groups of rats which were not exercised and also exercised from 1, 2, 3 up to 10 hours daily. The groups of rats which were exercised one or two hours daily consumed fewer calories than the unexercised rats, even though their energy requirements would obviously be greater. With exercise up to ten hours daily, the animal's food intake increased with increasing hours of exercise to maintain weight. At the peak of endurance of ten hours of exercise per day, the rats consumed inadequate calories for expenditure and lost weight. Thus within the normal range of activity the animal's appetite served to regulate intake to output to maintain body weight. Below the normal range the appetite is stuck at a minimum value higher than expenditure such that the animal accumulates excess energy as body fat.

Similar observations were made in a human study by Mayer et al. (1956) in which male workers in Bengal were studied because of their wide variation in physical activity and the uniform food availability. The workers who participated in light activity had the lowest caloric intake while sedentary workers ate more and were heavier. Those who performed heavy manual labor had a higher caloric intake but were not overweight. In normal activity, appetite reveals itself as a sensitive and reliable mechanism for equating energy intake to energy expenditure. Individuals below a

certain level of activity appear to have lost the mechanism for control of food intake and consume more calories than they expend. This relationship has been confirmed in rats but not in other species. Even though independent studies have not been conducted with man, a review of studies which have found the obese to be inactive with normal caloric intakes would support this regulatory concept (Margen, 1970).

This tendency towards obesity and inactivity may start early in life as indicated by a study of infants conducted by Rose and Mayer (1968). They found that those babies with extremes of body fatness, that is those one standard deviation above or below the mean showed a strong correlation between physical activity and food intake. The infants with the highest body weight as fat ate less and were less active than the infants with the lowest percentage body composition as fat.

Inactivity appears to be a major factor perpetuating obesity in overweight youngsters. Johnson (1956) conducted a study of the typical physical activity of two groups of twenty-eight high school girls by means of a recall of physical activity throughout the year as well as by a twenty-four-hour recall. From the data obtained it was shown that the obese were significantly more inactive than the non-obese. As the caloric intake of the obese was significantly lower than the non-obese, their obesity was apparently due to their relative inactivity.

Stefanik et al. (1959) compared the average daily caloric intake and activity of fourteen obese and fourteen paired-control-non-obese adolescent boys both during the school year and for eight weeks at a summer camp. The obese ate significantly less than the non-obese at both time intervals. The obese overate only in a relative sense as the energy expended was depressed, particularly in active exercises, when compared with the non-obese controls.

This pattern of inactivity may continue in adult life as the obese adolescent becomes the obese adult. The chances have been inferred by Mayer (1968) as follows. If both parents are obese, 80 percent of their children will be obese; if one parent is obese, 40 percent of their children will be; and if both parents are normal, the chance of overfatness is reduced to 7 percent.

In the study by Hutson et al. (1965) which was previously considered, individuals with the highest percentage of body fat spent significantly more of their time in less strenuous activities than those with lesser amounts of body fat. However, there was no clear-cut relationship between degree of body fatness and participation in moderate and strenuous activities. This could be due to the weighting of the data to the very light activity category since more hours of the day are spent in this category of activity.

For a study of obese and non-obese housewives Bloom and Eider (1967) developed a unique method of a shock timer