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

LENA JANE BARRETT

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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 Eiden (1967) developed a unique method of a shock timer attached to the knee of participants to measure the amount of time spent sitting and standing in a normal day. They found the obese spent on the average, sixty-five minutes more time in bed and seventeen percent more time sitting, while the non-obese spent three hours more per day standing than the obese. This study shows that the obese housewife spends less time in the standing position than the non-obese which implies that the obese were less active.

Dorris and Stunkard (1957) discovered from pedometer measurements that fifteen obese women walked less than half as much as fifteen non-obese controls. In a similar study of males, Chirico and Stunkard (1960) found that the obese were less active than the non-obese and expressed a preference for sedentary activities. However, there is less difference in activity patterns of the obese and non-obese males than of the two groups of females in the previous study.

Not all studies indicate a correlation between obesity and inactivity. In the study of fifty women conducted by Maxfield and Konishi (1966), the amount of activity of the obese and non-obese was determined by means of a pedometer. No significant differences were found between readings for the two groups.

McCarthy (1966) reports that the obese group of Trinidadian women were as active as the non-obese. The apparent absence of a difference in activity patterns of the obese and non-obese in these studies may be a reflection of the inadequacies of measurement of physical activity. Not only the amount of work done but the rate of action is important in assessing the energy expended in any given activity. The obese and non-obese may have the same amount of activity by these measures but expend different amounts of energy due to the manner in which they perform the activity. Many obese individuals with the same BMR as normal individuals require less calories to maintain their weight as they utilize less energy when sitting, walking or standing due to a tendency to work more slowly and efficiently (Durnin, 1955).

Using a motion picture technique, Bullen et al. (1964) compared the activity of obese and non-obese girls engaged in different sports at a summer camp. A significant degree of inactivity was found among the obese performing the same sport as the non-obese, since they did not exert themselves to the same extent.

From the review of literature it appears that the obese are more inactive and have a lower caloric intake than the non-obese, implicating inactivity as a major factor in the etiology of obesity. The studies which indicate no difference in the activity of the obese point to the problem of measuring the typical amount of energy expended by the obese as compared with the non-obese. Work is not a constant energy equivalent as there is a great deal of individual variation both between and within groups of obese and non-obese individuals (Passmore and Durnin, 1957). Curtis and Bradfield (1971), in their study of the caloric cost of housekeeping activities of six obese housewives found a wide variation in energy expenditure in the performance of the same task. For an accurate indication of daily energy expenditure, the caloric cost of the activity must be measured at the time the task is performed. Such studies have been attempted infrequently due to the complexity and lack of precision of the methods and procedures used to obtain these data on alive and intact man (Buskirk et al., 1963).

Many of the studies are an observation of the present behavior and metabolism of the obese and conclude the individual is obese because he behaves in a certain manner. However, that behavior may be modified as a result of becoming obese (Margen, 1970). Therefore, his present behavior may or may not reflect the original cause of the energy inbalance.

A more accurate approach would be to study the person in the developing stages of obesity. Here again difficulties arise in that weight gain may be very gradual and therefore impossible to determine by present methods and procedures.

Given the possible sources of error, the present studies are insufficient to draw any definite conclusions as to the causes of obesity; however, the observed tendency towards inactivity of the obese is of sufficient degree to warrant further study.

METHODOLOGY

Operation Recreation-Nutrition (RENU) was founded as a result of a National Conference on Fitness and Health held in Ottawa on December 4-6, 1972. The purpose of this program was to "provide motivation and diagnostic screening to ensure physical fitness and nutritional health for Manitobans" (RENU, 1974). For the present study consideration will be given to the information collected in the preliminary operation which took place from June 15 to August 26, 1973. During that time the sixteen member RENU team[2] travelled to a non-random group of nine rural towns. The towns were chosen on the basis of interest shown by the local health professionals and proximity to Winnipeg for the convenience of the "team."

Since the program was a free public service, all members of the community were eligible to participate. The age and sex distribution of the participants in each town are shown in Table 1.

In each clinic a continuous flow operation was organized to include medical assessment through history and examination, laboratory testing of blood and urine samples,

[2]The "team" consisted of one physician, three medical students, one physical education co-ordinator, four physical education graduates, one nutrition co-ordinator, four home economics graduates and two medical technologists.

Table 1

Number of Participants in each Town
Categorized as to Age and Sex

Age	Ste-Anne M	Ste-Anne F	Steinbach M	Steinbach F	Beausejour M	Beausejour F	St. Laurent M	St. Laurent F	Stonewall M	Stonewall F	Carman M	Carman F	Winkler M	Winkler F	Portage M	Portage F	Neepawa M	Neepawa F	TOTAL
20-29	14	18	14	22	3	6	8	8	5	6	9	9	4	8	16	25	9	11	195
30-39	19	23	13	16	6	9	3	7	4	6	6	7	6	5	19	17	9	9	184
40-50	17	21	14	13	8	15	4	6	6	12	6	6	8	7	11	21	8	11	194
51-60	16	8	17	14	10	6	4	6	3	11	7	8	10	7	12	21	7	15	182
61-	6	7	8	6	3	6	3	8	10	8	9	5	7	2	12	15	12	16	143
Total	72	77	66	71	30	42	22	35	28	43	37	35	35	29	70	99	45	62	898
Total for each town	149		137		72		57		71		72		64		169		107		

exercise testing and counselling and nutritional assessment and counselling. Only those procedures which involved collection of data pertaining to the present study will be described. These procedures, which were performed by the RENU team, include a measure of body composition to categorize the subjects as obese or non-obese; a test of physical fitness to divide the population into a fit and an unfit group; and a measure of daily food intake to determine the typical caloric intake of the subjects. With the results of these tests, there will be a comparison of the caloric intake and physical fitness of the obese and non-obese individuals. Also the fit and unfit will be compared as to caloric intake and body fatness. By so doing, the present study is an attempt to determine the more important factor associated with excessive body fatness, that is "overeating" or "under-exercising" or whether a combination of both is responsible for the accumulation of excessive fat and resultant obesity.

Body Composition

A measure of body composition is necessary to categorize the subjects as obese or non-obese. As noted from the review of literature, the body composition is a better indicator of obesity than measures of height and weight.

To determine the percentage body fat, the thickness of the skinfolds was measured at four sites on the body: supra-iliac, triceps, biceps and subscapular. Some authors believe that values from one or two sites, specifically triceps or subscapular, are indicative of body composition. Seltzer and Mayer (1965) have developed standards for obesity using only the measure of the triceps skinfold in millimeters. However, a measure of all four skinfolds is more representative of the distribution of fat than a smaller number and also a single small error in measurement becomes less important (Durnin and Rahaman, 1967).

Four physical education graduates measured the skinfolds on all subjects using a Harpenden skinfold caliper calibrated to exert a pressure of ten grams per square millimeter of jaw surface. Three consecutive readings were taken and the average of the three was recorded.

Prediction of percentage body fat was made using tables which give direct transformation of the total values obtained by skinfold measurements, to percentage of fat in the body. The values 20 ± 3 percent and 15 ± 3 percent fat of the total body weight for females and males respectively were set by RENU as allowable for physical and nutritional fitness (RENU, 1974). Above these margins the individual is considered overfat or obese, whereas within or below these margins the individual is considered "ideal."

Physical Fitness

In the initial interview, upon arrival at the clinic, the participants were questioned as to their physical activities, both recreational and at work. The purpose of these questions was to give an indication of the subject's typical activity patterns. However, this data is invalid, since the interviews were not conducted in a routine manner. A great deal of variation in the response was expected depending on the techniques used by the interviewer. Therefore, the individual's physical fitness was assessed instead, as an indicator of typical physical activity.

Various physical fitness tests were performed by the RENU team to measure the strength, power, endurance and flexibility of the subject. Of these tests the best single-overall evaluation of a person's general physical fitness is the measure of the maximum oxygen uptake (MVO_2) (Shephard, 1968, Astrand and Rodahl, 1970, Wessel and Van Huss, 1969). Therefore, in the present study the results of this test will be used to divide the population into physically fit and unfit categories for comparison with caloric intake and body fatness of the subjects.

The MVO_2 is a circulatory exercise test based on the linear increase in heart rate with increasing oxygen uptake or work load (Astrand and Rodahl, 1970). From the heart rate response the circulatory capacity can be evaluated. A physically active person is able to transport the same amount of oxygen at a lower heart rate than a physically inactive person.

To measure the MVO_2 the heart rate must have reached a "steady state" in which there has been an adaptation of cardiac ouput, heart rate and pulmonary ventilation, usually after four to five minutes of exercise at a submaximal work load. At this point the oxygen uptake corresponds to the demands of the tissues.

The Monark bicycle ergometer was used for this exercise test to provide an exact measurement of performed external work. For the six-minute bike ride, a graded and measurable load can be applied to each subject so that subjects with different work capacities would have approximately the same relative load. The work load was set to attain a submaximal work load at four to five minutes as indicated by a heart rate of approximately 150 beats per minute for young subjects and 125-145 beats per minute for subjects over forty years of age. The subject's heart rate was monitored during the test from the ECG to be sure sufficient load was given. On the sixth minute, the heart rate was recorded from results of the ECG. If the subject experienced pressure or pain in the chest or shortness of breath, the test was discontinued.

The heart rate for the sixth minute of exercise was used in a nomogram constructed for the prediction of MVO_2 in litres per minute (Astrand, 1960). A correction factor for age was applied since there is a reduction in maximal pulse rate with increasing age. Without this factor there would be an over-estimation of the MVO_2 of older subjects.

The MVO_2 in litres per minute was then divided by the subject's weight in kilograms, so that MVO_2 is measured in millilitres per kilogram per minute (ml/kg/min). Expressing the MVO_2 relative to body weight appears to be a strict penalty for the obese; however, in the context of fitness it is a fair penalty since the muscles of a heavy person must perform more work and the oxygen cost of all physical activities is increased by obesity (Shephard, 1972, Cooper, 1968, Gitin et al., 1974).

The standard error for MVO_2 on a single test is about 10 percent and up to 15 percent when the age factor for correction is applied (Astrand, 1960). Although the test is not completely reliable as other factors such as psychological stress, fear and excitement may affect the heart rate, the test is considered valid in making intra-individual or inter-individual comparisons (Shephard, 1968, Heppelinck, 1969).

The individual's MVO_2 values were compared to the "ideal", as shown in Table 2, which were used by the RENU team. The higher the MVO_2, the more efficiently is the oxygen being transported to the tissues and better physical condition is the subject. Therefore, those individuals at or above these standards were considered physically fit, whereas those below these values were considered physically unfit.

<u>Caloric Intake</u>

The nutrition component of the project included a twenty-four-hour dietary recall followed by counselling. For characterizing a group by mean intakes, the twenty-four-hour recall is considered the most efficient method of study (Ten State Survey, 1972; Nutrition Canada, 1973).

After a two-week training period at the beginning of

Table 2

Standard Maximum Oxygen Uptake (ml/kg/min)
Considered "Ideal" by "RENU"

Age	Males	Females
20-30	45	40
31-40	35	32
41-50	30	27
51-60	28	25
61-80	23	20

the project, the five nutritionists performed the dietary recalls on all subjects. Even though this data was collected by different people, interviewers with similar training and background and working as a team can obtain comparable data on dietary intake (Church et al., 1954). Each interview lasted an average of 15-20 minutes in which subjects gave information on foods consumed on the previous day, the amounts being estimated by use of the food model kits used in the Nutrition Canada Survey.

These kits were designed for Nutrition Canada in conjunction with a program for data processing. Only the alphabetic code of the amount of food consumed is required for computer analysis. Foods were also coded according to the food consumption tables which include 2,483 food items appearing in the USDA Handbook No. 8 (Watt and Merrill, 1963) plus additional codes for foods unique to Canada developed in the Nutrition Canada Survey (1973). The food codes and amounts were completed and checked by each of the interviewers, before being double checked by the nutrition co-ordinator of the project in an attempt to eliminate individual variation and errors.

Since the Nutrition Canada Computer Program was not available for use, the program developed by the Foods and Nutrition Department in conjunction with the Computer Centre here at the university was used to determine the nutrient values of the foods consumed. The food servings were converted to weight in grams using "Food Values of Portions Commonly Used" (Bowes and Church, 1966). The 2,483 food codes in Handbook No. 8 (Watt and Merrill, 1963) were used exclusively and those foods previously given Canadian food codes were changed to the closest substitute listed in Handbook No. 8. Both conversions were necessary to accommodate the use of the MEALS LB computer program. All calculations were completed by the same person to reduce human error as much as possible.

This data was punched on computer cards and analyzed for all nutrients including calories by the MEALS LB computer program. The average caloric intake of each group for both males and females was calculated. These calculations were completed only for those individuals who were 20 years of age and over and who indicated a typical dietary intake for the previous day.

The relationship between typical caloric intake and physical activity could only be studied in those individuals who were in a state of energy balance. Therefore, the subject's response to the questionnaire in the initial interview was used to determine whether the individual was maintaining a constant weight. The subjects were asked whether they had gained, lost or maintained weight within the last two months. Since individual fluctuation may be as much as 1-2 kilograms per day (Durnin, 1967), the subjects who reported a weight gain or loss of three pounds or less were considered to be maintaining their weight.

Statistical Analysis

The 839 participants were categorized as to age, sex, fit or unfit (on the basis of the MVO_2 values) and obese and non-obese (on the basis of percentage body fat). The significance of the proportions in each category was tested using a chi-square analysis.

The data from the participants who fulfill the criteria for the second phase of the study was compared as to actual values of MVO_2, percentage body fat and caloric intake. These participants were categorized as to obese and non-obese, age and sex to compare the MVO_2 values. An analysis of variance was used to test the significance of differences in physical activity (as measured by MVO_2) of the obese and non-obese. In a similar manner the fit and unfit were compared as to percentage body fat for each of the age and sex categories.

Using the mean values of caloric intake for each category, an analysis of variance was performed to test the significance of different sources of variation, individually and for effects of interaction, on the energy output.

RESULTS AND DISCUSSION

The people who attended the RENU clinic were not randomly chosen but were those who first took the initiative to phone the RENU clinic and make an appointment to attend. In promoting the project, the slogan "create a 'nu' you and come to RENU," implies that the old you is less desirable. Therefore, it was expected that a higher proportion of "health conscious" people would attend. This does not necessarily mean these people were more "healthy" than the typical population. There are also those who were concerned that they were perhaps "slightly" inactive or "somewhat" overweight but really wanted to be assured that they were not. Also some of the subjects came as referrals from other health professionals in the community and might be considered "unhealthy." Therefore the participants in the clinic were not expected to represent the typical population. In light of the nature of the sample, the results of body fatness, physical fitness and caloric intake are considered only in terms of these subjects without attempting to make inferences of a similar state to the total population.

Of the 898 adult participants in RENU, 839 (381 males and 458 females) completed the fitness tests and body fat measures. These subjects were categorized as to obese or non-obese according to the standards for body fat. Individuals above 18 and 23 percent body fat for males and females respectively, were classified as obese and the remainder were non-obese. Using the values calculated for MVO_2, the subjects at or above the standards recorded in Table 2 were categorized as fit, whereas those below the standards were categorized as unfit.

From the results presented in Table 3, it can be noted that 224 (58.8%) of the total of 381 males were unfit whereas approximately an equal number of males were obese and non-obese. A greater proportion of the females were unfit and obese. As shown in Table 4, 338 females (73.8%) of the total of 458 were unfit and 379 females (82.8%) were obese, the differences being significant as shown in Table 5.

There is a possibility that the standards used by RENU are not applicable and would reveal a similarly high proportion of unfit females in the total population. In this case either the standards may be too high or the total population is extremely unfit. From the interaction of obesity and fitness it would follow that the significantly larger number of obese participants would be associated with a higher proportion of unfit participants.

As shown in Table 3, there were fewer fit than unfit males as 157 (41.2%) of the total of 381 males were fit. The difference in number of fit and unfit males was significant as shown in Table 5. The difference arises due to the age groups not being uniformly fit as shown by the interaction of

Table 3

The Number of Males Classified According to Age, Obesity and Fitness

Age	Obese Fit	Obese Unfit	Non-Obese Fit	Non-Obese Unfit	Totals
20-30	2	35	14	38	89
31-40	17	30	25	13	85
41-50	13	29	23	16	81
51-60	15	27	23	7	72
61+	13	19	12	10	54
Totals	60	140	97	84	
	200		181		381

Total Fit = 157 Unfit = 224

Table 4

The Number of Females Classified According to Age, Obesity and Fitness

Age	Obese Fit	Obese Unfit	Non-Obese Fit	Non-Obese Unfit	Totals
20-30	17	77	7	16	117
31-40	13	55	18	13	99
41-50	22	65	6	5	98
51-60	19	64	4	4	91
61 +	11	36	3	3	53
Totals	82	297	38	41	
	379		79		458

Total Fit = 120 Unfit = 338

Table 5

Tests on Proportions and Independence of Classification Variables for Males and Females

	Degrees of Freedom	Chi-Square Males (n=381)	Chi-Square Females (n=458)
Fitness	1	11.78***	103.76***
Obesity	1	0.95	196.51***
Age	4	10.17*	24.36***
Age-Fitness	4	27.07***	3.61
Group 1 vs. others	1	25.86***	
Amongst others	3	0.88	
Age-Obesity	4	6.52	22.54***
Group 2 vs. others	1		17.50***
Amongst others	3		5.64
Obese - Fitness	1	21.83***	23.67***
Age - Obesity - Fitness	4	11.45*	3.88
Total	19	88.97	451.94

*** p 0.005
** p 0.01
* p 0.05

fitness with age. The youngest age group (20-30 years) had only 16 (18%) of a total of 89 who were fit whereas the other age groups had 46-53 percent who were fit. Using the chi-square analysis to separate the degrees of freedom in the age-fitness interaction, it was found that the youngest age group was significantly different from the other age groups. There was no significant difference among the other age groups in the number of fit and unfit. It seems that the youngest age group is more often unfit than the other age groups, perhaps reflecting the sedentary lifestyle of the younger generation. The older participants have only recently changed their lifestyle, being relatively active in their younger years, which would improve their present level of fitness (Astrand and Rodahl, 1970).

Again the validity of the standards should be questioned as the MVO_2 value may be relatively high for the youngest age group. In a recent study conducted by Shephard (1968), the MVO_2 values of 661 adults living in the Toronto area were determined using the submaximal treadmill test. The mean values were calculated for each decade for both males and females. When compared with the RENU standards, the mean values for the MVO_2 from this sample would be considered "fit." From this study, the RENU standards do not appear to be disproportionately high for the youngest age group, as this age group had much higher MVO_2 values than the other age groups. Since the standard appears to be reasonable, it seems likely that the present sample did not give a good representation of the youngest age group.

For the females there was a difference in percentage classified as obese among the age groups. There was an increase in the percentage of obese females with age (Table 4) the difference being significant as shown in Table 5. A closer examination of the data showed that 68.6 percent of the females in the second age group (31-40 years) were obese as compared to 80-91 percent in the other age groups. From the chi-square analysis a significant difference was found between the number of obese in this age group as compared with the other age groups which are not significantly different in themselves (Table 5). The significant difference among obese females in this age group may be due to the non-randomness of the sample.

Of the 200 obese males, 140 (70%) were unfit whereas there was approximately an equal number of fit and unfit in the 181 non-obese males (Table 3). The interaction of obesity and fitness was significant as shown in Table 5. In Table 4, it may be seen that 297 (78.6%) of the 379 obese females were unfit. The non-obese had almost an equal number of fit and unfit. As for the females the interaction was significant as shown in Table 5. It seems that the obese are more prone to being unfit, whereas the non-obese are equally likely to be fit as unfit.

Of the 839 participants considered thus far, 420 indicated a non-typical dietary intake for their twenty-four-hour recall and/or a gain or loss in weight within the last two months which invalidated this data for use in the present study. The remaining 419 participants (198 males and 221 females) are to be considered in the following analysis. Table 6 gives the numbers of subjects in the various classifications of age, sex, obesity and fitness which will be used in discussing their body fatness, physical activity and caloric intake.

All the data collected in body composition, physical fitness and caloric intake will be given in tables in the appendix. In this section of the paper the data will be presented in figures for easier comparisons.

Body Composition

The percentage of total body weight composed of fat was calculated from skinfold measurements and the mean values are shown in the appendix (Tables A1 and A2). Figures 1 and 2, for males and females respectively, give a comparison of the mean percentage body fat of fit and unfit subjects in each age group. With the exception of the oldest group of males (61 years and older), all the unfit subjects had a higher mean percentage body fat than the fit subjects. The difference between the fit and unfit, both male and female was significant as shown in Table 7.

According to Parizkova (1963), one of the most important factors influencing body composition is the intensity of physical activity. He found that there is a greater propor-

Table 6

Number of Participants both Male and Female Classified According to Fitness and Obesity (n=419)

	Male				Female			
	Fit		Unfit		Fit		Unfit	
Age	Obese	Non-Obese	Obese	Non-Obese	Obese	Non-Obese	Obese	Non-Obese
20-30	1	3	18	16	5	4	28	12
31-40	5	12	12	4	5	12	17	5
41-50	6	12	15	9	13	11	23	3
51-60	7	13	21	6	13	3	34	4
61 +	10	9	12	7	7	-	20	2
Totals	29	49	78	42	43	30	122	26

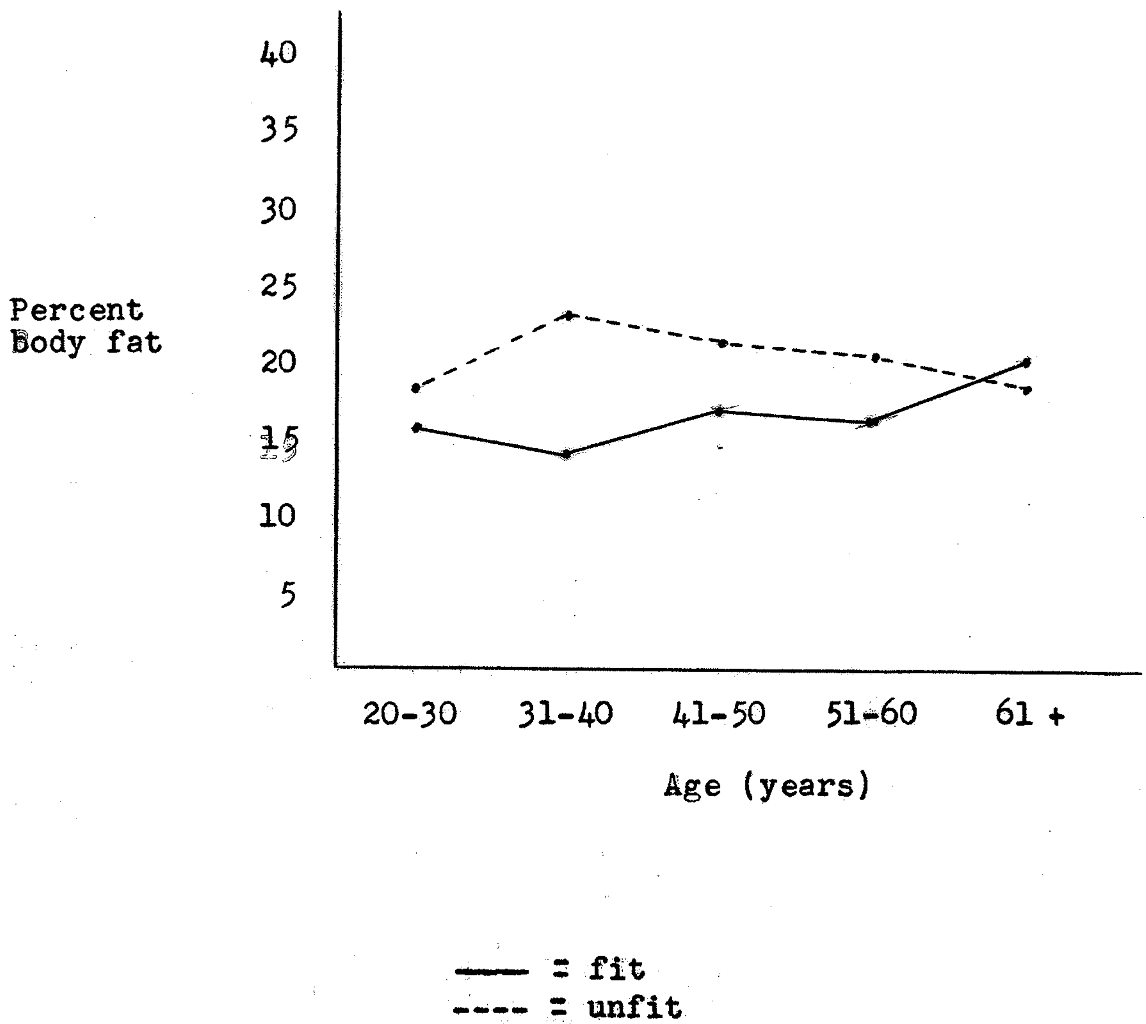

Figure 1

Mean Percentage of Total Body Weight Composed
of Fat of Fit and Unfit Males
in Each Age Group (n=198)

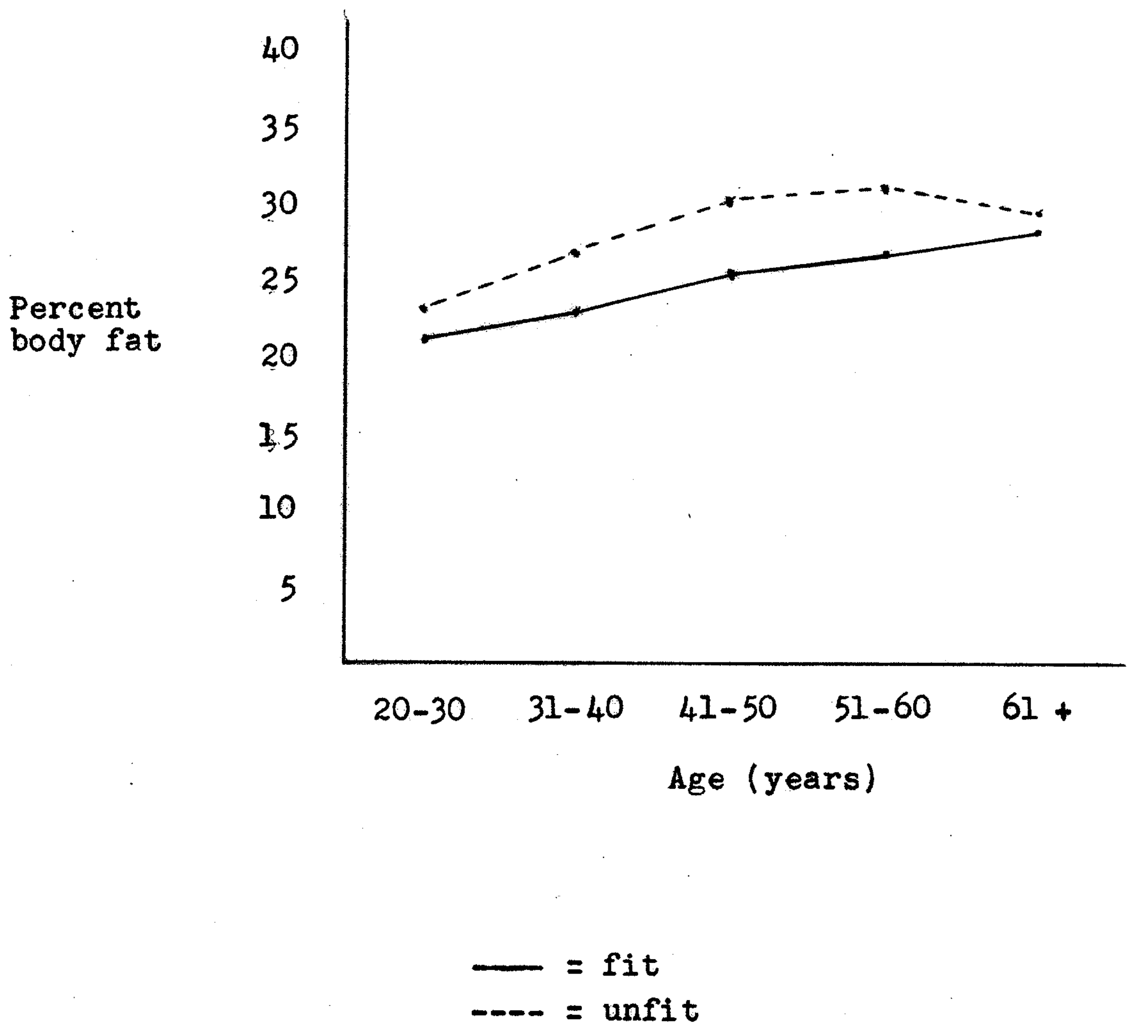

Figure 2

Mean Percentage of Total Body Weight Composed of Fat in Fit and Unfit Females in Each Age Group (n = 221)

Table 7

Analysis of Variance of the Mean Percentage of Total Body Weight Composed of Fat of Fit and Unfit Subjects in Each Age Group

Source	Degrees of Freedom		Males		Females	
			Mean Square	F	Mean Square	F
Fit vs. Unfit	1		489.99	12.23***	704.16	12.63***
Ages	4		218.85	1.37	372.93	7.26***
Fitness x Age	4		520.10	3.25	20.29	0.36
Between subclasses	9		1,109.84	[illegible]	253.00	[illegible]
	M	F				
Within subclasses	188	211	7,531.66		55.72	

*** p 0.005
* p 0.05

tion of lean body mass (LBM) and relatively less fat for physically active individuals than for those not accustomed to physical activity. Therefore, the significantly greater amount of body fat may be an indication of less participation in physical activity by the unfit subjects tested in this survey.

For males, there was no significant difference among the age groups in the mean percentage body fat (Table 7). An increase in percentage body fat is expected to occur with age due to changes in cellular components along with a decrease in physical activity (Bray, 1970). However, an increase in body fat with age does not necessarily occur if the individual keeps up the physical activity of his youth (Shephard, 1968). It would appear that these males maintained the same level of physical activity with age as reflected by the lack of a significant change in body fatness. The mean percentage body fat after the age of 30 years is greater than 18 percent, which is indicative of obesity for males. Therefore, the physical activity although unchanged with age seems to be insufficient to maintain the "ideal" body composition.

As shown in Figure 2, the mean percentage body fat of females increased from 23% at 20-30 years to 30% at 51-60 years, the difference being significant (Table 7). As observed above, an increase in body fat with age may reflect changes in cellular activity and the decline of physical activity.

Physical Fitness

From the participant's performance on the six-minute bicycle test, the maximum oxygen uptake (MVO_2) was calculated in millilitres per kilogram per minute (ml/kg/min). From Figures 3 and 4 of males and females respectively it is obvious that the non-obese have higher values for MVO_2 than the obese, with the exception of the females 61 years of age and over. The overall mean values of MVO_2 for the obese and non-obese males were 27.63 ml/kg/min and 33.69 ml/kg/min respectively (Table B1). Similarly it was noted that the obese females had a mean MVO_2 of 25.59 ml/kg/min whereas the non-obese had 32.52 ml/kg/min (Table B2). On the basis of the significantly lower MVO_2 values of the obese as compared to the non-obese (Table 8), the obese may be considered less physically fit.

The decrease in MVO_2 with increasing age is evident in Figures 3 and 4 for males and females respectively. The difference amongst the age groups is significant as shown in Table 8. In adult life it is expected that both sexes will have a steady loss of aerobic power due to a decrease of endurance fitness and concurrent changes of activity (Shephard, 1968; Cumming, 1967). Therefore the changes which occur with age when compared to the standards reported in Table 2 follow the same general pattern although the mean values for the MVO_2 in this study tend to be lower than the "ideal."

The exception to the trend of decreasing MVO_2 with age

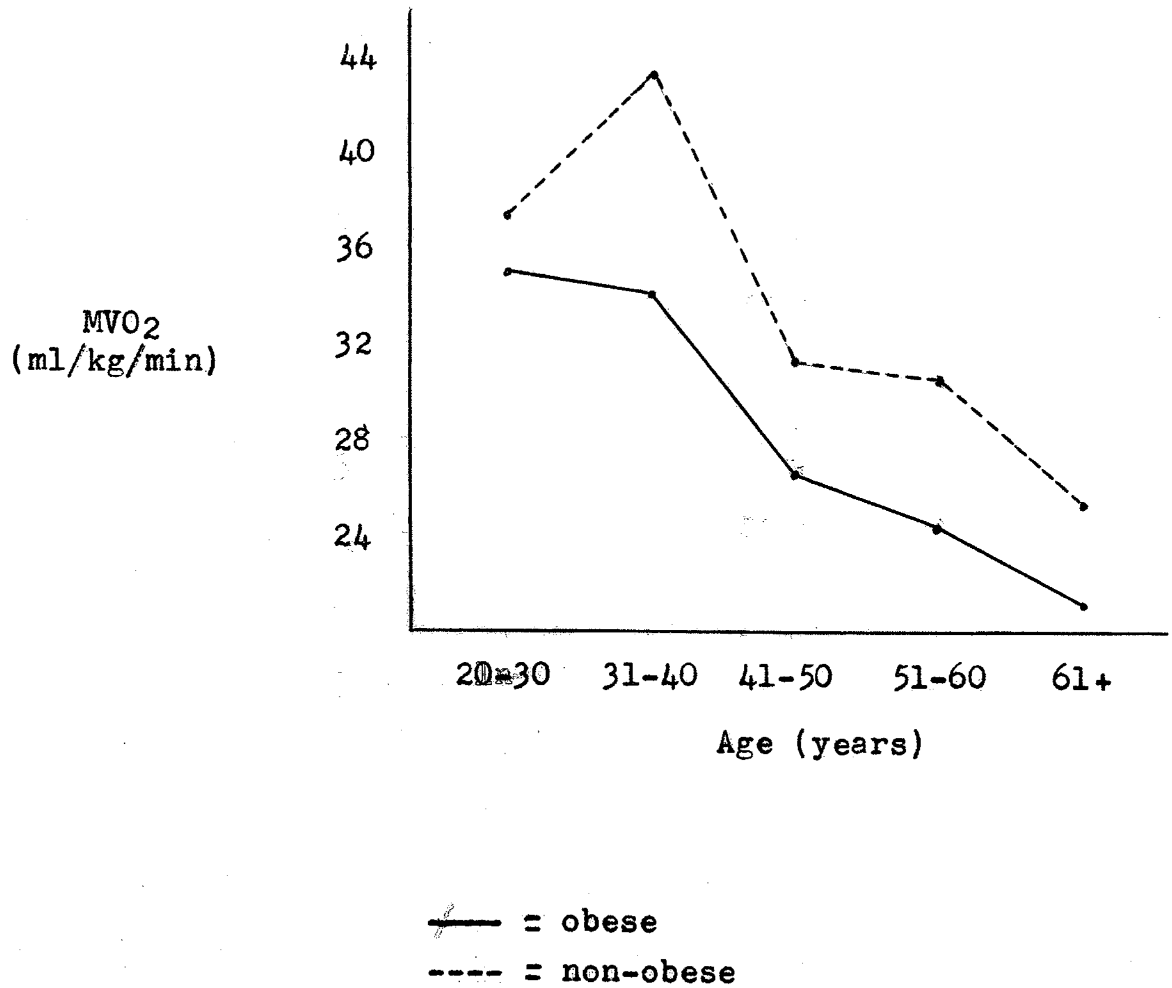

Figure 3

Mean values of MVO_2 for Obese and Non-Obese Males in Various Age Categories

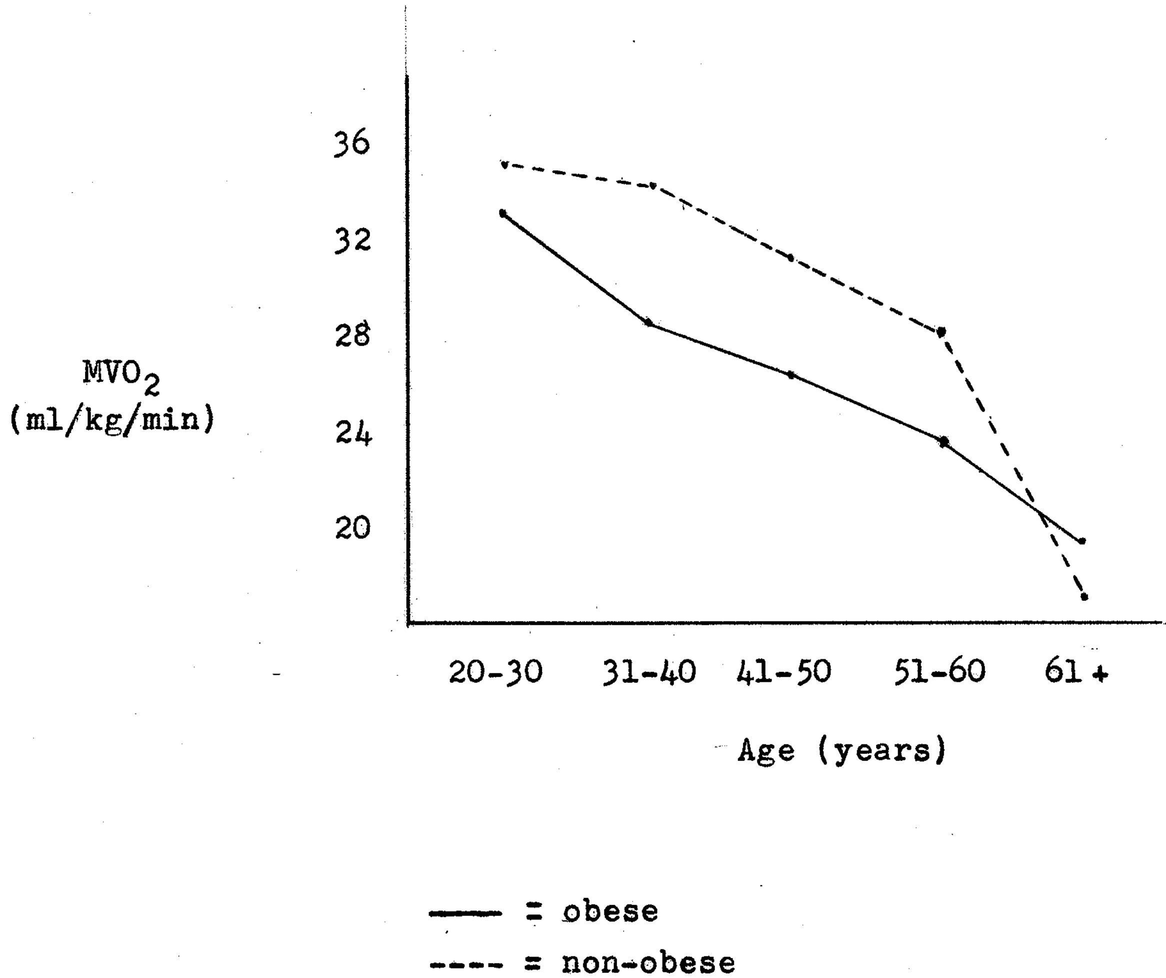

Figure 4

Mean values of MVO_2 for Obese and Non-Obese Females in Various Age Categories

Table 8

Analysis of Variance of Mean Values of MVO_2 for Obese and Non-Obese Subjects in Each Age Group

Source	Degrees of Freedom	Males: Mean Square	Males: F	Females: Mean Square	Females: F
Obese vs. Non-Obese	1	1,807.93	17.60***	692.92	16.39***
Age	4	1,607.80	15.66***	1,174.83	27.79***
Obesity x Age	4	70.18	1.18	56.13	1.33
Between Subclasses	9	904.85		770.11	
	M F				
Within Subclasses	188 211	59.38		42.28	

*** p 0.005

was the youngest age group of males (Figure 3). Their mean MVO_2 value of 36.42 ml/kg/min was lower than the mean of 38.81 ml/kg/min for the males in the next age group (31-40 years) and the standard of 45 ml/kg/min. As noted previously, this group of males appeared to be atypical. It may be that the youngest age group with each generation is becoming less and less fit, but more likely that this was a non-representative sample.

There is some question as to the validity of using the MVO_2 expressed in terms of weight. The obese who are heavier would have a lower calculated MVO_2 even though the active cell mass, which accounts for most of the requirement for oxygen, would be less than for the non-obese person of the same weight (Buskirk and Taylor, 1957). However, the penalty is thought to be warranted considering the hinderance to oxygen carrying capacity imposed by excess adipose tissue and increased oxygen consumption as a result of adipose tissue metabolism (Gitin et al., 1974). Thus the MVO_2 is not appreciably affected by excessive body fat and this measure is considered equally applicable to both obese and non-obese (Davies, 1968).

The MVO_2 is dependent on an individual's level of physical activity (Saltin and Astrand, 1967; Hermansen and Andersen, 1965). With an increase in activity the oxygen carrying capacity of the tissues is increased and general fitness is improved. Therefore, the significantly better performance of the non-obese as compared with the obese may indicate more participation in physical activity of the non-obese subjects in this study.

Caloric Intake

Based on the twenty-four-hour recall, the caloric intake for the previous day was calculated for the 419 participants. Without combining the groups of males and females there was an obviously higher caloric intake of the males as seen in the Appendix in Tables C1 and D1 for males and females respectively. As shown in Table 9, the difference between the sexes was significant, an observation which has been well documented. Not only are males larger in body size which would account for an increase in caloric requirements, but the BMR is higher. Due to the characteristic male musculature with more active muscle tissues and less fatty tissue, more energy is required for metabolic activities (Guthrie, 1971).

The decline in caloric intake with age which may be noted in Figure 5 was found to be significant (Table 9). The decreased energy requirement with age is in part due to an increase in body fat and relative decrease in LBM which results in a lower BMR. From the Canadian Dietary Standard (1964), the BMR is reported to decrease 2½ percent per decade after the age of 25. Since these subjects have shown a larger decrease than 2½ percent per decade, the difference in energy requirements could be due to a decrease in physical activity with age.

There was little difference between the mean caloric intake of groups 31-40 years of age and 41-50 years (2,257.74 and 2,260.85 calories respectively) as seen in Table E. Referring to the same data compiled for males and females individually (Tables C1 and D1) only the females ages 31-40 had a lower caloric intake than the next age group. Women of this age could be more concerned about controlling their weight after the child-bearing years when they were most active. With a decrease in activity these women may consiously decrease their caloric intake to maintain their weight.

In Figure 6 it can be noted that the fit had a higher mean caloric intake than the unfit, for all age classifications. The difference was found to be significant as shown in Table 9. The fit subjects, who are more physically active to maintain their fitness, require a higher caloric intake than the inactive unfit subject to maintain the energy balance. Apparently appetite acts as a regulatory mechanism which increases with an increase in activity (Mayer, 1974).

As shown in Figure 7, the non-obese had a higher mean caloric intake than the obese of all ages, the difference being significant (Table 9). The difference in caloric intakes may be due to the relative inactivity of the obese and consequent lower caloric requirements than the non-obese who seem to be more physically active.

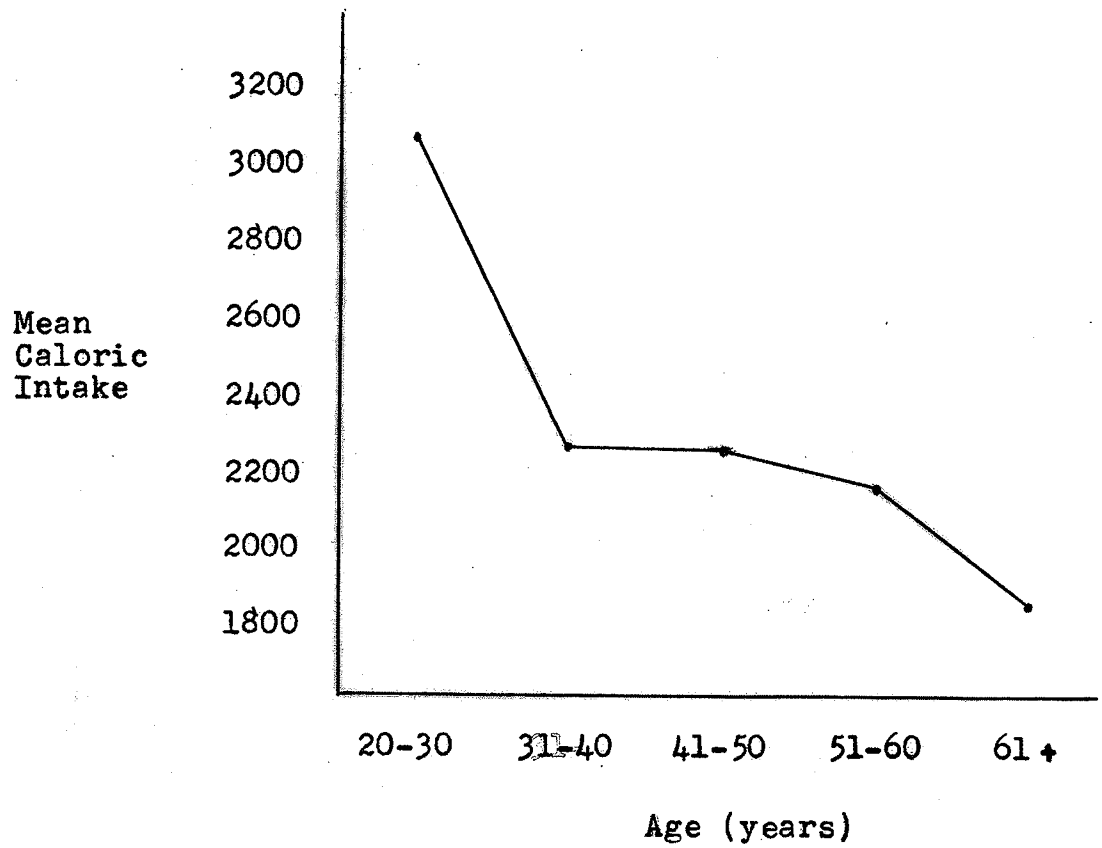

Figure 5

Mean Caloric Intake of Subjects
in Each Age Group

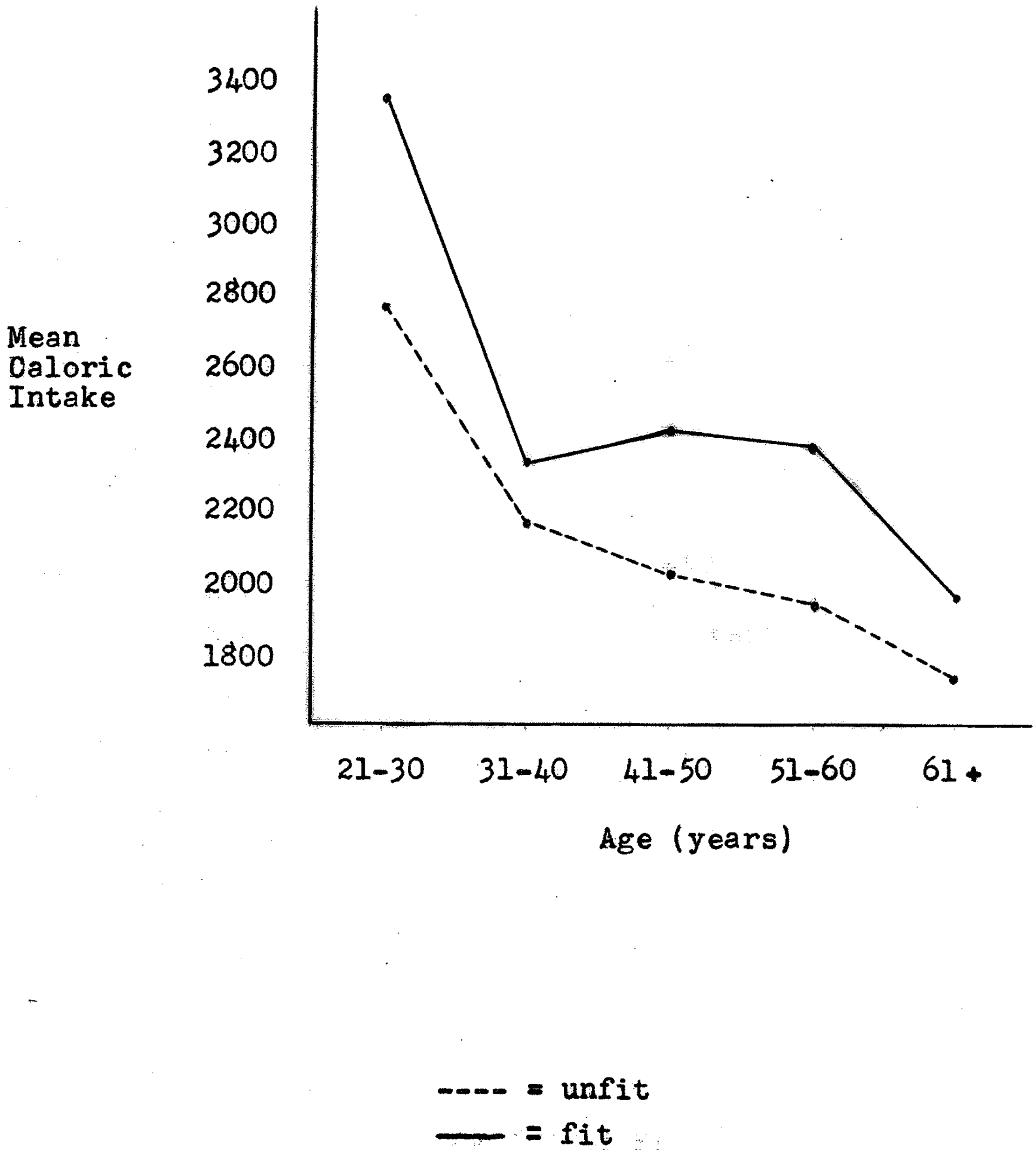

Figure 6

Mean Caloric Intake of Fit and Unfit Subjects in Each Age Group

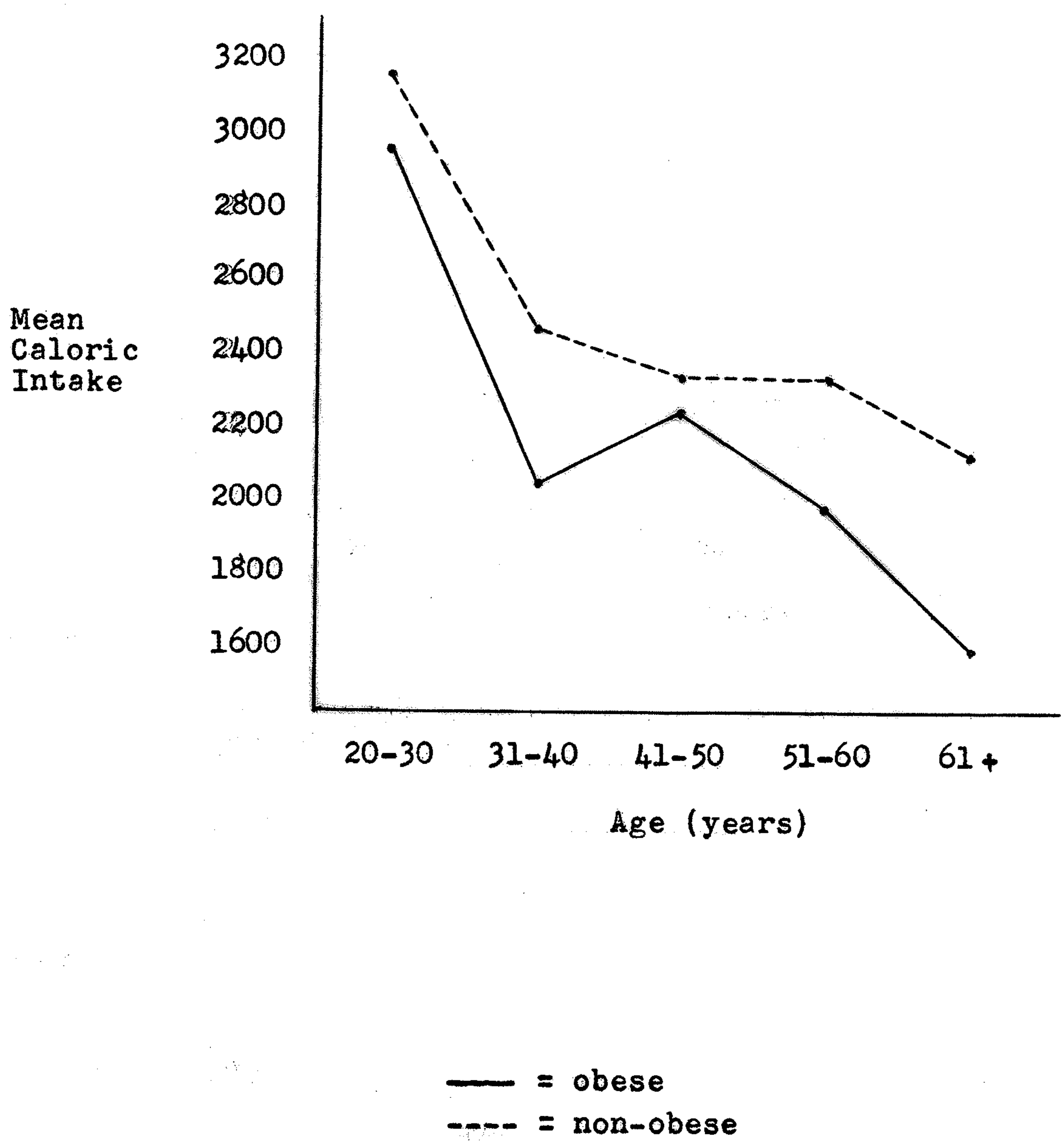

Figure 7

Mean Caloric Intake of Obese and Non-Obese Subjects in Each Age Group

Table 9

Analysis of Variance of the Mean Caloric Intakes of the Subjects Categorized According to Sex, Fitness, Age and Obesity

Source	Degrees of Freedom	Mean Square	F
Sex	1	7,771,321.66	30.70***
Fit	1	1,090,862.00	4.31*
Sex x Fit	1	51,430.40	0.20
Age	4	1,614,969.41	6.38*
Sex x Age	4	188,319.46	0.74
Fit x Age	4	60,744.42	0.24
Sex x Fit x Age	4	99,124.29	0.39
Obesity	1	1,007,002.33	3.98*
Sex x Obesity	1	43,499.30	0.17
Fit x Obesity	1	101,237.80	0.40
Age x Obesity	4	57,850.16	0.23
Sex x Fit x Obesity	1	683,540.12	2.70
Sex x Age x Obesity	4	215,376.73	0.85
Fit x Age x Obesity	4	207,830.60	0.82
Sex x Fit x Age x Obesity	4	30,041.25	0.12
Error within	379	253,102.98	
Total	418		

*** p 0.005
* p 0.05

SUMMARY AND CONCLUSIONS

During the summer of 1973, 898 adult volunteers participated in a recreation-nutrition project entitled RENU. These people were counselled in physical fitness and nutrition based on their performance on the various tests to assess their physical fitness, body fat and caloric intake.

From the determination of percentage body fat of 839 adults and comparison with RENU standards, the prevalence of obesity was evident, particularly for the females. To determine whether these results were typical of the Canadian population, the data may be compared with data from the Nutrition Canada survey. There is some difficulty in such a comparison due to the different method used in Nutrition Canada to assess obesity, that is by ponderal indices, as well as a different categorization in age groups. However, it appears that the RENU clinic attracted a greater percentage of obese females and fewer obese males than is typical of the Canadian population. Even though the proportion of obese participants is not necessarily representative of the total population a comparison of the caloric intake and physical fitness yields meaningful information on the differences between the obese and the non-obese.

The once popular notion that the obese are consuming relatively large quantities of foods has been rejected by a number of studies. The present study lends support to this observation as the results from the 419 subjects, whose data was valid, shows that the obese had a lower caloric intake than the non-obese. In the initial interview the participants had indicated that they were maintaining a constant weight. Therefore, it would seem that the obese individual requires a lower energy input to maintain his weight and thus a lower energy output to maintain the energy balance.

Using the measure of the MVO_2 as indicative of physical fitness, the obese were less fit than the non-obese. To attain a higher level of fitness, more physical activity is required. Based on this assumption the less fit would be less physically active. Therefore, the obese would be relatively less physically active than the non-obese. A further assumption may be made that the disruption in the energy balance and resultant obesity occurs because of physical inactivity rather than excessive caloric intake (relative to the non-obese).

Since the participants were studied in the static phase of obesity, inactivity may also be a consequence of obesity rather than the initial cause. A number of other factors have been associated with obesity such as meal frequency, nutrient content of the diet, genetics, hormonal and enzymatic disturbances as well as psychosomatic and neural problems. All of these factors individually or jointly may contribute to the cause and persistence of obesity. Thus the identification of the causes of obesity involves dealing with a complexity of factors and a multitude of problems to measure the presence of differences in these factors between the obese and the non-obese.

The techniques of assessing physical fitness and caloric intake as well as the standards to which these are compared have not been standardized. Even the definition of the state of obesity itself has not been agreed upon. There is a need for more research to establish such standards so that further studies will be more accurate. Ideally, a calorimeter would be used to assess man's energy needs in a balance between food intake and energy expenditure as well as during the developing stages of obesity when the subject is gaining weight. However, the method of calorimetry would be very costly and is not presently feasible.

As an alternative, a continued study similar to RENU utilizing data as to activity patterns as well as physical fitness and caloric intake would be of value in assessing the components of the energy balance. A further study utilizing this data might include a consideration of some other contributing factors which were recorded, specifically the relationship of meal frequency and diet composition to obesity.

One of the difficulties inherent in any study is the attainment of a representative sample of the population. In a further study there should be more attention given to obtaining a random sample, so that more positive implications may be made with reference to the entire population.

As a result of the study of the RENU data from the summer of 1973, the prevalence of obesity has been identified. The obese do not appear to be consuming excessive calories relative to the non-obese, but their caloric consumption may be "excessive" relative to their energy expenditure. Apparently the increasingly common sedentary lifestyle has contributed to the "growth" of the population. Thus any attempts to treat the problem of obesity should emphasize the importance of a combination of diet and exercise, as physical inactivity has been closely related to the presence of obesity.

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APPENDIX

Table A1

Mean Values for Percentage Body Composition as Fat of Fit and Unfit Males in Various Age Groups (n=198)

Age	n	Fit	n	Unfit	n	Mean for Age
20-30	4	16.03	34	18.00	38	17.82
31-40	17	14.13	16	22.73	32	18.30
41-50	18	17.43	24	21.55	42	19.78
51-60	20	16.91	27	20.78	47	19.13
61 +	19	20.39	19	18.34	38	19.37
Mean	78	17.23	120	20.03		

Table A2

Mean Values for Percentage Body Composition as Fat of Fit and Unfit Females in Various Age Groups (n=221)

Age	n	Fit	n	Unfit	n	Mean for Age
20-30	9	21.49	40	23.94	49	23.49
31-40	17	23.19	22	27.37	39	25.55
41-50	24	25.11	26	30.17	50	27.74
51-60	16	27.03	38	31.72	54	30.33
61 +	7	28.77	22	29.88	29	29.61
Mean	73	24.99	148	28.43		

Table B1

Mean Values of MVO_2 (ml/kg/min) for Obese and Non-Obese Males (n=198)

Age	n	Obese	n	Non-Obese	n	Mean for Age
20-30	19	35.26	19	37.58	38	36.42
31-40	17	34.08	16	43.83	33	38.81
41-50	21	26.61	21	31.39	42	29.00
51-60	28	24.25	19	30.79	47	26.89
61+	22	21.32	16	25.41	38	23.04
Mean	107	27.63	91	33.69		

Table B2

Mean Values of MVO_2 (ml/kg/min) for Obese and Non-Obese Females (n=221)

Age	n	Obese	n	Non-Obese	n	Mean for Age
20-30	33	33.66	16	35.52	49	34.27
31-40	22	28.34	17	34.83	39	31.67
41-50	36	25.68	14	31.56	50	27.33
51-60	47	22.17	7	26.50	54	22.73
61+	27	19.33	2	16.70	29	19.15
Mean	165	25.59	56	32.52		

Table C1

Mean Caloric Intake of Males Categorized According to Age, Fitness and Obesity (n=198)

Age	Fit				Unfit			
	n	Obese	n	Non-Obese	n	Obese	n	Non-Obese
20-30	1	4,490.18	3	3,761.40	18	2,888.15	16	3,703.16
31-40	5	2,331.57	12	3,075.26	12	2,369.32	4	3,310.46
41-50	6	2,876.94	12	2,633.10	15	2,805.36	9	2,454.70
51-60	7	2,553.70	13	2,472.22	21	2,285.85	6	2,373.77
61 +	10	1,959.02	9	2,722.18	12	1,765.75	7	2,333.38
Total	29	14,211.41	49	14,664.16	78	12,114.43	42	14,175.47

Table C2

Analysis of Variance of Mean Caloric Intake of Males

Source	Degrees of Freedom	Mean Square	F
Fit	1	334,284.47	2.02
Ages	4	1,342,338.93	8.14***
Age x Fitness	4	126,833.22	0.77
Obesity	1	315,957.01	1.92
Fit x Obesity	1	129,329.83	0.78
Obesity x Age	4	231,670.84	1.40
Fit x Age x Obesity	4	82,714.05	0.50
Error	178	164,967.23	
Total	197		

*** p 0.005

Table D1

Mean Caloric Intake of Females Categorized According to Age, Fitness and Obesity (n = 221)

Age	Fit				Unfit			
	n	Obese	n	Non-Obese	n	Obese	n	Non-Obese
20-30	5	2,474.69	4	2,664.82	28	1,992.96	12	2,518.59
31-40	5	1,688.41	12	2,207.44	17	1,749.92	5	1,329.55
41-50	13	1,626.85	11	2,523.02	23	1,537.35	3	1,629.51
51-60	13	1,549.60	3	2,925.67	34	1,593.71	4	1,535.31
61 +	7	1,185.68	-	1,931.03°	20	1,451.62	2	1,418.72
Total	43	8,525.23	30	12,251.98	122	8,325.60	26	8,431.68

° calculated as a missing value

Table D2

Analysis of Variance of the Mean Caloric Intake of Females

Source	Degrees of Freedom	Mean Square	F
Fit	1	808,530.76	9.01***
Ages	4	452,349.21	5.04***
Age x Fitness	4	41,691.59	0.45
Obesity	1	734,710.09	8.19***
Fit x Obesity	1	654,893.00	7.30***
Obesity x Age	4	50,115.42	0.56
Fit x Age x Obesity	4	155,397.45	1.73
Error	201	83,736.32	
Total	220		

*** p 0.005

Table E

Mean Caloric Intake of Fit and Unfit Subjects
Categorized According to Age and for
Each Age Group (n=419)

Age	n	Fit	n	Unfit	n	Mean for Age
20-30	13	3,347.77	74	2,775.72	87	3,061.74
31-40	34	2,325.67	38	2,189.81	72	2,257.74
41-50	42	2,414.98	50	2,106.73	92	2,260.85
51-60	36	2,375.30	65	1,947.16	101	2,161.23
61+	26	1,949.48	41	1,742.37	67	1,845.92
Mean	151	2,482.64	268	2,152.36	419	2,317.50

Table F

Mean Caloric Intake of Obese and Non-Obese Subjects Categorized According to Age (n=419)

Age	n	Obese	n	Non-Obese
20-30	52	2,961.50	35	3,161.99
31-40	39	2,034.81	33	2,480.68
41-50	57	2,211.63	35	2,310.08
51-60	75	1,995.72	26	2,326.74
60 +	49	1,590.52	18	2,101.33
Mean	272	2,158.83	147	2,476.16