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Estimates of energy expenditure in women and a biofeedback device for weight loss

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ESTIMATES OF ENERGY EXPENDITURE IN WOMEN AND A BIOFEEDBACK DEVICE FOR WEIGHT LOSS

By

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DISSERTATION

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For Elizabeth, Paul, and Anne

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Finally, I thank all behaviorists who have tried to render psychology into a science. Ultimately, answers to behavioral problems such as eating disorders will be found by those working in the experimental analysis of behavior; and for this understanding, I owe my deepest debt to B. F. Skinner.

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ABSTRACT

ESTIMATES OF ENERGY EXPENDITURE IN WOMEN
AND A BIOFEEDBACK DEVICE FOR WEIGHT LOSS

by

Sandra Rutter
University of New Hampshire, September, 1990

Researchers have been unable to discern the relationship between energy expenditure and obesity because there has been no reliable, unobtrusive method to capture daily activity. Single-plane accelerometers have been developed, using microcomputer technology, which may provide a means for measuring expenditure in human subjects. The Caltrac Personal Activity Computer® has shown high test-retest reliability and a strong relationship to several measures of expenditure in some laboratory tests. In Experiment 1, 40 university women (mean age = 19.15 yr) wore Caltracs during waking hours for either three or six consecutive days, with the devices programmed to count activity regardless of individual metabolism. Pearson product-moment correlation coefficients showed a moderate negative relationship between Caltrac counts and Body Mass Index (BMI) ($r = -.47$, $p < .01$) for the second three-day period ($N = 26$) but there was no correlation between Caltrac counts for the first three days and any measure of body weight or fat. Subjects may need a few days to become accustomed to the device before counts are analyzed when it is used in natural, free-ranging settings.

There was no correlation between estimates of weekly caloric expenditure determined from the Paffenbarger Survey of Physical Activity and measures of body weight and fat or the Caltrac. There was a moderate positive

correlation between skinfold measures and the total amount of weight lost and gained over the past year ($r = .46$, $p < .001$), indicating that fatter subjects had more labile weight.

In Experiment 2, 15 women (mean age = 19.4 yr) who were at least 30 percent fat, with weight ranging from 139-234 lb (mean weight = 178.37 lb) wore Caltracs for four weeks which were programmed to reflect individual expenditure in calories. Subjects recorded caloric intake into the Caltrac which displayed energy balance in the form of net calories (intake minus output). Mean weight loss was <1 lb, not significantly different from control subjects ($N = 5$) who weighed daily and graphed their weight. The Caltrac may be an improved method for estimating energy expenditure but it did not help subjects lose weight.

SECTION I

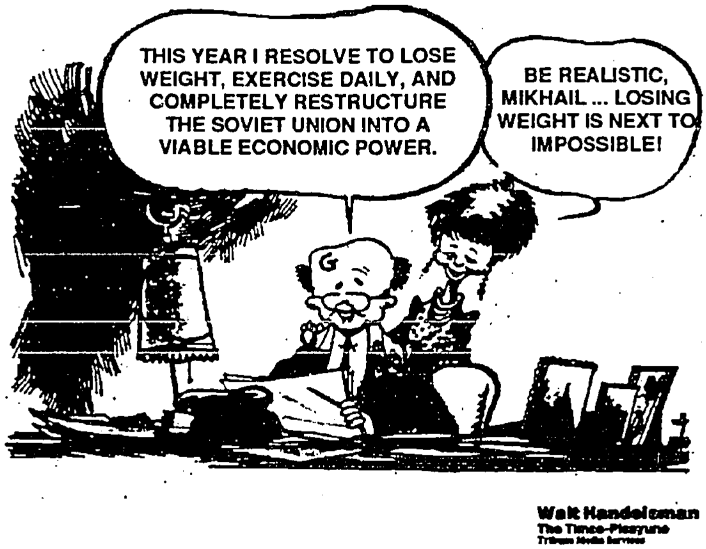

Figure 1

This cartoon was in the Sunday, 31 December 1989 issue of the *New York Times*, and acknowledges some of the amazing changes that occurred on our planet during the closing days of the 1980s. The humor of the cartoon lies in the fact that the sudden relinquishment of control held by one of the two or three major political systems in the world for the past seventy years is easy when compared with losing weight. In other words, political miracles are much more likely than losing a few pounds.

For those who seem to have been blessed with either the biology or will power that enables them to maintain a lean physique, it may be untenable that others, while expressing a desire for thinness, don't seem to be able to "just say 'No'" to extra snacks and helpings.

Those who have not been endowed with the American ideal of slenderness may also wonder why they are lacking in strength and resolve to do what needs to be done to lose weight. Perhaps these people curse the fate of those who are able to eat as much as they want, as one famous actress claims, while remaining rail thin. Perhaps they curse their own character when well-meaning friends describe how they "made up their mind" to lose weight, and so they did.

In any case, the overweight person is considered at fault for his or her condition and, according to one survey, being overweight is worse than being a shoplifter, a cocaine user, or a communist (Weintraub & Bray, 1989). People who are overweight suffer employment, social and sexual discrimination (Brownell & Foreyt, 1985). Prejudice against the overweight extends to very young children who label fat children "stupid, ugly, dirty, naughty and lazy" (Maddox, Back & Liederman, 1968).

It would seem likely that overweight individuals would suffer significant pathology because of social discrimination, but this does not seem to be the case except for the massively obese (Wadden & Stunkard, 1985). Women, in general, seem to be especially affected by excess weight because they suffer more social stigmatization than men (Wadden & Stunkard, 1985). Obesity in women is more prevalent than in men at all ages (Bray, 1987); for example, in a study of 17,000 Finnish adults (Rissanen, Heliövaara & Aromaa,1988), one-sixth of all women were severely overweight, and after age 40, obese women significantly outranked obese men in number.

In the United States, obesity is "epidemic" (Kannel, 1983) and its prevalence is increasing, with approximately 34 million adults in the overweight category, and 12 million of these people are classed severely overweight

(Kissebah, Freedman & Peiris, 1989). Obesity has become a major concern to the health professions since people who are overweight are at greater risk for serious disease, including coronary heart disease (CHD), hypertension, diabetes mellitus, gallbladder disease, and certain types of cancer (Bray, 1986). Increasing risk for these diseases is a function of increased fatness and, concomitantly, when excess weight is lost, risk for these diseases decreases, although not at the same rate. For example, Bray noted that during periods of caloric deprivation during World War II, there was almost no existing hypertension in deprived areas; however, risk for cancer is only reduced, not eliminated at reduced weight.

Measures of Weight and Fatness

Height-Weight Tables

In order to determine risk factors due to obesity, researchers have categorized individuals by amount of either excess fat or excess weight. There is a difference between weight and fatness: Weight is measured in pounds or kilograms and increased weight is usually a function of increased height. The weight that is considered normal, or within a normal range, can be found on a height-weight table. The most widely used height-weight table was published by the Metropolitan Life Insurance Company in 1959 and revised in 1983. The original table was comprised of data pooled from almost 5 million life insurance policies issued between 1935 and 1953; the revised table was based on data from 4.2 million policies issued between 1950 and 1971.

Of interest is the effect of body weight on longevity, and the tables list the optimal weights at which adults are considered to live longest for their height, gender and frame size (Brownell, Rubin & Smoller, 1988). It can be said that a person is overweight if he or she has a weight that is higher than the acceptable range for that person's height, gender and frame size.

There are several problems with height-weight tables. First, one must make an arbitrary assumption as to the point of deviation from the normal range, which covers at least 20 pounds (lb) on the Metropolitan Life tables (Bennett, 1987). A further problem is that the tables are not representative of the entire American population in that they include data on a disproportionate number of white, middle- and upper-class males and include no data on adults over 59 years of age (Foreyt, 1987). Finally, the tables can only be a guide to weight, not fatness. A person can be overweight without being "over fat"; for example, football players are usually heavy but have very little body fat, and some thin people who are in poor condition are "flabby" because they have an excess of fat for their size and weight.

To differentiate between weight and fat, some researchers use the term "overweight" to refer to weight in excess of the normal range on height-weight tables, while "obese" refers to excess body fat (Brownell et al., 1988). The two terms are often used interchangeably because increasing overweight usually reflects increasing obesity for most people, so the height-weight tables can provide some indication of fatness. Nevertheless, the information they provide is limited for two reasons: (1) Height-weight tables do not account accurately for body fat amount; and (2) A person outside the normal range is deviant according to a nonstandardized amount. For example, if the normal weight for an individual ranges from 130 to 150 lb and the person weighs 160 lb, is that person 10 lb or 20 lb overweight?

Body Mass Index (BMI)

Because height-weight tables do not give an accurate assessment of body fat, the Quetelet or Body Mass Index (BMI) was devised using a power function that gives the maximum correlation of weight with body fat and the minimum correlation with height (Gray, 1989). The BMI is calculated by dividing weight (in kilograms) by the square of height (in meters). It can be adjusted for age, showing minimum mortality for people at each decade of life (Bray, 1987). Typical recommendations for age-adjusted levels of the BMI are as follows (Bray, ibid.):

Age Group (in years)	BMI (kg/m^2)
19-24	19-24
25-34	20-25
35-44	21-26
45-54	22-27
55-64	23-28
65+	24-29

These values can be used for men and women (Gray, 1989), and they have a strong correlation with body fat in large heterogeneous samples, especially when BMI is above 30 (Bouchard, 1989). Bray (1986) estimates overweight to be BMI between 25-30 and obesity to be BMI above 30.

When compared with standard height-weight tables, the BMI has a higher correlation with body fat, the ranges are easy to learn, and they apply to both men and women. Also, the BMI can be adjusted for age whereas height-weight tables usually are not. This is important because percent body fat increases with increasing age. For these reasons, BMI is increasingly used to assess body weight normality (Bouchard, 1989) and may be the most useful way to determine degree of overweight (Bray, 1989; Gray, 1989).

Skinfold Measures

The BMI does not indicate amount of body fat but there are specialized instruments and methods designed to estimate the amount of fat on the body. The most simple and inexpensive method uses skinfold calipers. Because a large percentage of body fat lies under the skin, the thickness of a fold picked up by the calipers is a good measure of subcutaneous fat (Garrow, 1978).

Estimates differ as to the percentage of fat that lies under the skin rather than the fat that surrounds organs and is too deep to be measured by calipers. Garrow (1978) says that most stored body fat is subcutaneous, while McArdle, Katch and Katch (1981) give a lower estimate of about 50 percent. Therefore, calipers only measure a portion of body fat and this portion is undetermined and different from person to person. Skinfold measures are also prone to error if more than one person takes measurements (Gray, 1989); and if the observer is inexperienced, measures will probably vary between subjects due, in part, to imprecise technique. Nevertheless, an estimate of body fat can be obtained using this method, and it is inexpensive and simple to perform. At least four sites should be measured: biceps and triceps (upper arm), subscapular (shoulder blade) and suprailiac (the pelvis) (Garrow, 1978). McArdle et al. (1981) also suggest measurement of the abdomen and upper thigh.

Hydrostatic Weighing

There are several methods for measuring fatness that are more accurate than skinfold measures; however, while obtaining increased precision, they are more costly and time consuming. Hydrostatic or underwater weighing, for example, is quite precise, but requires total immersion of the subject in a tank of water in order to determine body density, which is then converted into percent fat by a simple equation.

Bioelectric Impedance Analysis (BIA)

A relatively new method for measuring fatness is bioelectrical impedance analysis (BIA), wherein a portable device measures resistance to electrical current that is run through the subject's hand and foot. It is assumed that water comprises a constant fraction of fat-free mass and, because resistance is inversely proportional to total body water, through which the current travels, fat-free mass can be calculated by dividing total body water by the constant fraction. Amount of fat is the difference between fat-free mass and body weight (Gray, 1989).

According to Gray (1989), this procedure has a high correlation with underwater weighing (0.96), while Ross, Léger, Martin and Roy (1989) obtained correlations from 0.63 to 0.89 when three different equations were used to calculate impedance on subjects that was obtained before and after weight loss. Thus, the BIA method seems to be sensitive to changes in body composition resulting from participation in a diet and exercise regimen. The use of this technique may be "limited" however (Baumgartner, Chumlea & Roche, 1990), for several reasons. Resistance of tissue varies among individuals due to abnormal levels or distributions of body fluid, and equations do not necessarily capture each subject's variance; at best, there will be "inescapable" error ranging from 1-3 percent; slight displacement of electrodes will increase error; skin temperature variability will increase error; and age, gender and ethnicity affect the estimate.

Circumference Measures

While skinfold measures and BIA give an estimate of total body fat, it is useful to have an accurate measure of localized fat distribution. It may be that the fat distribution pattern is an important determinant of health risk from obesity (Gray, 1989; Krotkiewski, Björntorp, Sjöström & Smith, 1983), because the amount of fat in the abdominal region is an indicator of risk for CHD. Determining fat distribution is easily made with a tape measure, and the method is easy, inexpensive, and requires little skill. Also, circumference measurement seems to be more precise than skinfold determination (Gray, 1989.). Finally, circumference measures are a good way to rank subjects by order of fatness (McArdle et al., 1981) or by waist-to-hip ratio, which gives the proportion of fat on the waist to that on the hips.

Defining Obesity

Once it has been determined what proportion of an individual is comprised of fat, it is then necessary to apply some standard for categorizing level of obesity. This is a rather arbitrary procedure, because many different standards have been applied. Researchers often base obesity on excess body fat, with an amount that is 30 percent or greater in females and 25 percent or greater in males the lower limit of obesity (Bray, 1987; Gray, 1989; McArdle et al., 1981). When obesity is determined by weight rather than fat, researchers often use 20 percent above normal weight as the lower limit for obesity (Bray, 1987; Brownell et al., 1988; Kannel, 1983; Stunkard, 1984; Van Itallie, 1979). This is because studies by life insurance companies have indicated that people who are greater than 20 percent overweight are at substantially greater risk for mortality (Gray, 1989).

Obesity is further categorized by severity. Mild obesity is from 20 to 40 percent overweight and is the most common form of the disorder, comprising about 90 percent of obese persons (Stunkard, 1984). Moderate obesity is considered 40 to 100 percent overweight (Brownell & Foreyt, 1985), while severe obesity is greater than 100 percent overweight (Brownell & Foreyt, ibid.). While severe obesity presents the most serious complications and health risk, only about one percent of all obese persons are considered severely obese (Wadden & Stunkard, 1985).

Whether an individual is a few pounds overweight or severely obese, it is likely that he or she has fashioned a tremendous amount of effort into the quest for thinness. Attaining this goal is an unlikely event. Brownell has said that one is more likely to recover from most forms of cancer than to reach and maintain ideal weight for five years (Brownell, 1982). Because obesity is a condition that is apparently caused at least in part by voluntary behavior, it seems incongruous that so many people suffer from consequences of behavior they can seemingly avoid.

The primary goal of the first section of this dissertation is to clarify this seeming contradiction. In order to understand the physiological causes and effects of overeating, the first two topics will examine the fat cell and the physiology of eating. Included in these topics will be a discussion of obesity in the laboratory, primarily with rats, how obesity can be genetically or surgically induced, and how normal-weight rats can become fat for life by feeding them food typically enjoyed by most people. The rat is commonly used in laboratory research in obesity because its weight can be studied and manipulated in ways that would be unacceptable in human research; also, many manipulations mirror effects on humans when they engage in similar eating and dieting patterns.

The remaining four topics of the first section explore the various options available to the overweight person who wants to become thinner. Researchers have become aware in the past few years that weight loss and permanent maintenance of that loss can only be effected by increased exercise, as well as diet. The subsection on exercise will explain why exercise is a crucial part of a weight-loss regimen. Because there seems to be a lifestyle difference between people who are normal weight and overweight, one topic will explore the difference in the behaviors, both eating and lifestyle, of the normal- and overweights. Finally, the available methods for losing weight by modifying eating will be examined. A topic will be devoted to the progress of behavior modification in the weight-loss arena because the techniques that were developed by behavioral researchers seemed to hold much promise for overweight people. It is important to understand why that promise failed to materialize into substantial weight loss for the most part, and why researchers are exploring other weight-loss methods.

Lipids

The normal-weight adult human body is comprised of about 15 to 30 percent fat (Gray, 1989), which consists of esters of fatty acids (Garrow, 1978), and is stored in specialized fat cells called adipocytes or lipocytes (Nisbett, 1972). Adipose tissue is the major expandable depot for energy storage (Bray, 1983), and is approximately 80 percent fat (Garrow, 1978). The primary function of adipose tissue is to store energy in the form of triglycerides and release the stored lipids as fatty acids when they are needed by the body (Smith, 1981). This tissue may vary in size more than any other organ in the body (Sjöström, 1980).

Hypertrophy

Adipose tissue in the average adult human contains about 30 billion adipocytes (Hirsch, Fried, Edens & Leibel, 1989) which are embedded in a matrix of fibrous tissue containing blood vessels and many diverse cellular elements. Each adipocyte contains a single droplet of triglyceride which weighs about 0.5 μg, although the triglyceride may weigh from a few tenths of a microgram to 2 μg (Faust, 1984). The fat cell is therefore capable of expanding and contracting to accommodate varying amounts of lipid. In obese rats, for example, fat cells are filled with at least twice as much lipid as the fat cells of normal-weight rats. The fat cell can change its diameter at least tenfold to accommodate stored triglyceride (Smith, 1981), and Sjöström (1980) has measured fat cells ranging in diameter from 10 to 200 microns. This 20-fold variation in cell diameter corresponds to an 8000-fold variation in volume or body weight. The condition of enlarged fat cells is known as *hypertrophy*, and can exist in humans and other organisms as well as rats. It is widely agreed (Hirsch, Fried, Edens & Leibel, 1989) that adipocyte size changes quite readily and that animals at any stage of overweight have hypertrophic fat cells.

It is difficult to specify the ideal fat cell size required for normal weight because cell size interacts with cell number, and both cell size and number interact with the organism's age; for example, during the first year of human life there is a marked increase in cell size (Sjöström, 1980; Oscai, 1973), followed by decelerated size increase until early adulthood. By about age 20, fat cell size usually stabilizes, although with increasing obesity, the fat cell increases in size. In an adult woman carrying a normal amount of body fat, with each fat cell holding a lipid content of about .55 μg, a weight gain of 50 lb might increase the lipid in each cell to about 1.5 μg (Faust, 1984). If she returns to normal weight, her fat cells would again hold lipid weighing about .55 μg for each cell.

Salans, Horton and Sims (1971) studied five male prisoners of normal weight who volunteered to reduce physical activity and overeat for several months. The subjects gained an average of 35.6 lb (range 19.8-41.8 lb), which was a 20.9 percent increase in weight. During weight gain, fat cell size increased significantly, but when the study ended, all men lost weight easily and quickly, with fat cell size returning to normal, although cells in two of the volunteers were smaller than before the study and, in one volunteer, some of the cells were larger. These results indicate that temporary weight perturbations can have a permanent effect on fat cell size, and in subjects whose weight has previously remained within the normal range throughout their lifetime.

Hypercellularity

The fat cell can increase in size only to some maximum, and if the individual continues to store fat after this maximum point is reached, preadipose cells differentiate and form new fat cells. This condition is known as *hypercellularity* or *hyperplasia*. New adipocytes cannot be formed by multiplication of the existing mature adipocytes (Green, 1983), but they can be formed either before or after birth, and have been found in young, obese children who have more (6 to 10 x 10^{10} as opposed to 2.5 to 5 x 10^{10}) fat cells than normal-weight adults (Collipp, 1980). Obese persons can have up to five times as many fat cells as normal-weight persons (Foreyt, 1987).

The factors regulating the transformation of preadipocytes or the terminal differentiation of preadipocytes into adipose cells *in vivo* are unknown (Hirsch et al., 1989), but the number of fat cells can increase in adults as a result of great increase in body weight and a concomitant increase in cell size (Sjöström, 1980). Hirsch et al. mention two lines of evidence for fat cell number to increase in adult laboratory animals: (1) When cells are removed from fat depots, there is often spontaneous cell replacement; and (2) following prolonged feeding of palatable diets, fat cell number increases, especially in the retroperitoneal depots. There is also evidence that the number of fat cells increases in adult laboratory animals during exposure to cold temperatures (Sjöström, 1980), and

Sjöström contends that there is no long-term (greater than 10 years) indication that fat cell number is fixed in adult humans. Evidence supporting fat cell number increase in adult humans has come from Sjöström's laboratory in which he studied young adult and middle-aged patients with hypercellular obesity. Adipose tissue cellularity was observed in five obese women examined at five- to eight-year intervals. The women gained an average of 4-7 lb per year and, in four of them, both number and size of fat cells appeared to increase over time.

Hypertrophy vs. Hypercellularity

Sjöström (1980) postulates two types of obesity, one being hypertrophic or moderate, which is completely explained by increased fat cell size, and the other being hypercellular, which is explained primarily by increased fat cell number. All obese subjects are hypertrophic; however, subjects who are severely obese are probably hypercellular as well.

Adult-onset obesity primarily involves enlargement of the fat cells with lipid (Bray, 1983), and this hypertrophic obesity seems to correlate with an abdominal or android fat distribution. People who are hypertrophically obese seem to have been normal-weight children and gained weight during pregnancy or adulthood. The Prison Study of Salans et al. (1971) supports this theory because, after the study terminated, the previously normal-weight volunteers had no trouble losing the excess weight they had agreed to gain. The subjects' adipose tissue never became hypercellular; the fat cells merely enlarged.

On the other hand, people who are hypercellular were often overweight children. Sjöström (1980) examined adipose tissue in 18 grossly obese young girls before they obtained nutrition and exercise therapy, and 20 months following treatment. Number of fat cells remained unchanged in 17 nonobese girls, but the number of cells in the obese girls increased in spite of their average improved position on a height-weight chart.

Hypercellular obesity probably exists if the individual is grossly obese, having a body weight more than 75 percent above normal (Bray, 1989). If a person diets to lose weight, fat cells can shrink in size, but number of fat cells, once formed, never decreases (Nisbett, 1972). Furthermore, each time body weight is elevated over previous levels, new fat cells may form which are not eliminated during short-term weight reduction, during which time cell size may decrease sharply, but there is no reduction in the number of differentiated adipocytes (Hirsch et al., 1989). There is no research demonstrating a decrease in fat cell number following weight-reduction programs that have been followed for up to one year (Sjöström, 1980) although some individuals may lose fat cells when they diet (Garrow, 1978).

The implications of this research are profound for the person attempting to lose weight and maintain the weight loss. For some people, every extra pound gained makes future weight loss more hopeless because, with increased weight, the individual may have increased the number of permanent adipocytes in the body. Sjöström calls this a "biological trap."

<u>Hypercellularity and Long-Term Obesity</u>

The amount of fat any individual has is a function of the number and size of one's adipocytes (Nisbett, 1972), but long-term fatness in humans is determined primarily by the number, rather than size, of fat cells. Björntorp and Sjöström (1971) found a positive correlation of .71 between fat cell number and body fat in 37 obese subjects, while there was no correlation ($r = .13$) between body fat and fat cell size. Similarly, when Poehlman, Tremblay, Després, Fontaine, Pérusse, Thériault and Bouchard (1986) overfed healthy, young, adult male monozygotic twins, there was a strong within-pair resemblance for changes in percent body fat, body weight, fat mass, and subcutaneous fat, but there was no relation within pairs for fat cell size changes. The findings of Björntorp and Sjöström, and Poehlman, et al. suggest that degree of hypercellularity has a linear relation to degree of fatness, but there does not seem to be a relation between fat cell size and degree of fatness.

Determining Hypercellularity

Determining adipocyte hypercellularity is considerably more difficult than determining hypertrophy (Hirsch et al., 1989). Methods used to determine hypercellularity depend on accurate estimates of total body fat and accurate sampling from fat depots representing average size of fat cells. Bray (1983) notes that accurate measurement of body fat requires sophisticated techniques, which include measurements of body density, determination of fat or water by isotopic or chemical dilution, and the measurement of potassium (^{40}K). These methods are not widely available, and there is not yet a direct method for determining the total number of fat cells *in vivo* (Sjöström, 1980). Fat cells can be measured only by dividing total body fat by the weight of some average fat cell. This method is only as accurate as the method employed to determine total body fat and the accuracy for determining the average weight of fat cells. When there is a measure of body fat and an estimate of average cell size, the number of fat cells can be estimated (Bray, 1989). The procedure involves the removal of small fragments of subcutaneous tissue into a syringe and the obtained fat cells are isolated and counted. In this manner, the number of fat cells is determined for a known weight of fat tissue, and the average quantity of fat per cell is determined by dividing the quantity of fat in the sample by the total number of fat cells present (McArdle et al., 1981). Because fat cells differ in size from region to region, cell number estimate should be based on the average of fat cell sizes from more than one location (Bray, 1989).

Responses of Hypertrophic and Hypercellular Obesity to Weight Loss

From outward appearances, hypertrophic and hypercellular obesities are identical, and two similarly appearing women can weigh the same but each woman may have a different type of obesity (Brownell & Foreyt, 1985). The hypertrophic woman has a normal number of fat cells but they are enlarged. When she loses weight, she will continue to have a normal number of fat cells that become normal size. The hypercellular woman, however, can diet to reduce her fat cell size to normal, but will maintain the increased number of cells. If her fat cells are reduced to normal size, the hypercellular woman will still have more body fat because she has more fat cells. The only way she can reach normal weight is to maintain her fat cells at a smaller-than-normal level (Brownell & Foreyt, 1985; Faust, 1984).

Faust and Miller (1983) reduced rats to nearly 50 percent normal body weight and found that at starvation levels there was no detectable loss of fat cells. They conclude that "alterations of diet cannot be used to eliminate existing fat cells." Restricted food intake can reduce and maintain fat cell size to below normal; however, with refeeding, weight gain occurs until the cells attain normal size.

After rats gain weight due to a high-calorie diet, and they are then placed on a low-calorie diet, they often maintain the elevated weight (Van Itallie, 1979). This may result primarily from the increase in the number of fat cells acquired during weight gain, and the extra cells may account for the difficulty in returning to normal weight after long-term obesity.

Sjöström (1980) questions whether or not hypercellular obesity in humans should be treated at all because of the difficulty hypercellular patients have losing weight and the almost impossible task they have maintaining weight loss. The best treatment for the hypercellular person, according to Sjöström, is to prevent further weight increase.

Physiology of Feeding

Foods are chemical mixtures which are partially converted into protoplasm within the gut, are then released into the bloodstream, and enter the tissues (Wurtman & Wurtman, 1984), a process known as "anabolism." The essential chemicals, or nutrients, are continuously required by the cells, and when the organism is not digesting these nutrients, hormones control their release into the bloodstream from reservoirs in the tissues. The hormone insulin, for example, controls the uptake of glucose into the cells from the bloodstream. Glucose, a simple molecule of sugar, is the end product of all carbohydrates and is used by all cells as a source of energy (Mirkin, 1988). If it is not used immediately, glucose is stored as glycogen, a chain of glucose units, in the liver and skeletal muscles. When output exceeds intake, short-term energy needs can be met by the glycogen stores (Garrow, 1978). Larger needs must be met from fat stored as adipose tissue and from lipid stores in muscle cells because glycogen storage capacity in the body is limited to under 3000 kcal. When the liver and muscles are saturated with glycogen, any excess glucose is converted into fat.

The most important function of fat in the body is a store of energy (Hervey, 1969). Because living organisms constantly require energy, if there were no available store, the organism would have to continuously consume energy, in the form of food, to meet the body's constant demand. If the stored energy remains a constant size, the mature organism will maintain a constant weight over time. Weight does not change when the organism is in energy balance, but when the balance is positive, more food is consumed than expended, and the extra energy is stored as fat, or adipose tissue. An excess of adipose tissue is thus a problem of energy balance (Gray, 1983) and, when this happens, weight gain occurs. Eventually, body weight levels off. The reason for this leveling of body weight is unknown (Hernandez & Hoebel, 1980) but, even at a higher weight, we can say that when body weight is unchanged over time, the individual's intake and output are equal to each other. We must therefore examine separately the processes resulting in weight gain and those which maintain the individual in energy balance, even when weight is above normal.

Weight Gain

The Hypothalamus

Weight is gained because organisms eat more food energy than their body expends. Overeating occurs because either plentiful, good food is very rewarding to some people, or their phyisiological regulatory mechanisms do not work properly. There are several laboratory models supporting both arguments. A common technique for inducing obesity in the laboratory rat is to lesion the ventromedial hypothalamus (VMH) because, for some reason, the VMH-lesioned rat overeats and gains weight. The amount of overeating and, hence, weight gain, is a function of the size of the lesion (Hernandez & Hoebel, 1980), with larger lesions resulting in greater weight gain. Rats with VMH lesions often double normal body weight, although the amount of weight gained by VMH rats is determined by their weight when lesioned (Hernandez & Hoebel, 1980). If weight gain is induced before lesioning, post-lesioned rats will gain little weight, or may even lose weight to attain the level of excess fatness that apparently is dictated by the size of the lesion. When that level is reached, the rats maintain energy balance and, hence, stable weight.

Rats with VMH lesions also show enhanced sensitivity to tactile, olfactory, and gustatory stimuli (Grossman, 1984; Hernandez & Hoebel, 1980). If quinine is put in their food, VMH rats drastically reduce food consumption and often reduce their weight to or below those of nonlesioned controls. These rats are therefore called "finicky," because if their food is made even mildly distasteful, VMH rats will eat very little. Because of this, researchers conclude that the VMH rat does not defend its weight (Keesey & Corbett, 1984), because it has become very sensitive to external stimuli (Grossman, 1984). For example, VMH rats not only eschew bitter food, they abstain from eating tasty food if they have to work to obtain it. Some hypothalamic lesions cause excess consumption of sweetened food (Hernandez & Hoebel, 1980), and if food is available during the normal sleep cycle, a VMH rat may eat instead of sleep. This sensitivity to external cues corresponds to Schachter and Rodin's (1974) reports that some obese people are very sensitive to external food cues in that they eat large amounts of easily obtainable good-tasting food but seem disinterested in bland or tasteless food, or food they have to work for.

In contrast to weight gain and increased sensitivity to food stimuli seen in the VMH-lesioned rat, the animal with a lesion on the lateral hypothalamus (LH) shows a response deficit to sensory stimuli, and a diminished tendency to eat (Hernandez & Hoebel, 1980). The LH rat maintains weight at a chronically reduced level (Keesey & Corbett, 1984).

Because researchers have observed specific effects of variously located hypothalamic lesions in rats, they have concluded that energy regulation is primarily controlled by the hypothalamus (Hernandez & Hoebel, 1980).

Behaviors following ventromedial and lateral hypothalamic lesions suggest there is a lateral hypothalamic feeding system which is engaged in a "start-feeding process," and a medial hypothalamic satiety system which is engaged in a "stop feeding" process (Grossman, 1984).

The proprioceptive manifestation of these systems is known as "hunger" or "appetite." Hunger has been defined by Garrow (1978) as a sensation "which makes one want to eat," and appetite as a sensation "which makes one want to eat a particular food." In either case, the hypothalamus plays a major role (Grossman, 1984); for example, Hernandez and Hoebel's (1980) statement that certain hypothalamic lesions lead to an increased consumption of sweets indicates the hypothalamus may influence what organisms eat as well as how much they eat. Thus, the hypothalamus does not simply generate signals to start and stop eating; it is a place where nerve fibers bring together many different interacting signals (Garrow, 1978). Hernandez and Hoebel (1980) have noted that some taste nerves go from the tongue into the hypothalamus, and the trigeminal nerve, which circuits the jaw, is indirectly connected with the hypothalamus. Some hypothalamic lesions affect sensitivity around the mouth, and if the trigeminal is cut, an animal will starve rather than eat, behavior that is similar to rats with LH lesions.

Genetically Induced Obesity in Rats

A second way in which laboratory rats' weights are changed is by breeding rats that maintain abnormally large amounts of adipose tissue. These fatty mutants (*fa/fa*), bred by Zucker and Zucker, are the result of a recessive allele from the mating of two heterozygous lean rats (Foch & McClearn, 1980; Keesey, 1980; Keesey & Corbett, 1984). The Zucker fatty is usually sterile, is always obese, and maintains its excess adiposity when fed a diet that maintains normal weight in other strains. Deb and Martin (1975) fed Zucker fatties the same amount of food as age-matched Zucker leans who were fed ad lib. After 11 weeks, the lean rats were 6 percent fat and weighed 301g and the fatties were 39 percent fat and weighed 328g.

The Zucker fatty's obesity is the result of a single overriding gene that causes obesity regardless of the confluence of any other genes possessed by the organism or influence from the environment (Foch and McClearn, 1980). This does not negate the possibility that, without this dominant gene, other, less effective alleles could exist at a large number of loci and generate obesity in other species. It is likely that some forms of obesity stem from single genes and others are polygenic (Foch & McClearn, 1980). In either case, no genetic marker for obesity in humans has been found (Faust, 1984), and a search for such a marker has been complicated by the fact that there are at least 16 models of laboratory animal-induced chronic obesity (Hoebel, 1984), and three models of human obesity: hypercellular (or hyperplastic), hypertrophic, and a combination of the two.

One of the primary reasons it is believed that there are different types of obesities is that animals made obese in different ways respond differently to environmental manipulations. Whereas the VMH-lesioned rat does not defend its obesity when food does not taste good or when it must work for food, the Zucker fatty seems to do anything necessary to maintain its elevated weight (Keesey & Corbett, 1984), including eating quinine-flavored food (Foch & McClearn, 1980). Another difference between the Zucker fatty and the VMH rat is that the VMH rat is hypertrophic while the Zucker fatty is both hypercellular and hypertrophic (Keesey, 1980). This supports the hypothesis that animals with an above-normal number of fat cells defend excess weight, whereas animals with a normal number of fat cells that are enlarged lose weight when tasty food is not easily accessible.

Genetic Obesity in Humans

Keesey (1980) suggests that the Zucker fatty is a good animal model for some human obesities in that the Zucker fatty has an abnormally high number of fat cells, and maintains its weight in spite of dietary challenges, although there is indication that obese humans may be as finicky as the VMH-lesioned rat (see Van Itallie, 1984). Similar to the Zucker fatty, humans who have a disproportionate number of fat cells maintain elevated weights in spite of numerous attempts to lose weight. Research indicates this condition may be genetically influenced; for example, the obese young girls treated by Sjöström (1980) had increases in fat cell number even while improving their position on a height-weight chart, while same-aged normal-weight controls showed no fat cell increase during the 20-month period. For some people, then, fat-cell proliferation may be an inevitable expression of genotype.

Some obesity researchers believe that the number of fat cells in an individual is determined primarily by heredity (Collipp, 1980 ; Nisbett, 1972) and that, given the right combination of genes, obesity is as inevitable as juvenile diabetes mellitus. Collipp (1980) notes that when both parents are obese, 70 percent of their children are obese; when only one parent is obese, the incidence of obesity in their children is less than 10 percent. Of those obese children, 80 percent will become obese adults (Brownell & Kaye, 1982). Brownell, Kelman and Stunkard (1983) call childhood obesity one of the "most refractory of all common disorders in children," and waiting for a child to outgrow an obese condition is waiting for an "unlikely event" (Brownell, 1984). Sjöström (1980) has found that young adults with hypercellular obesity gain from about

4-6 lb/year and, although young people can be obese without being hypercellular, most obese children have many more fat cells than a normal-weight adult (Collipp, 1980).

Twin studies have examined the influence of genetics by comparing monozygotic (MZ) and dizygotic (DZ) twins. Stunkard, Foch and Hrubec (1986) compared BMI in 4000 twin pairs over a 25-year period. Correlations were slightly lower after 25 years (.74 for MZs as opposed to .85 25 years earlier, and .34 for DZs compared to an earlier .46) for both types of twin pairs, but it is evident that twins having identical genes also maintain very similar lifetime weights, while twins not having identical genes show much greater weight variability among pairs. Also supporting genetic control over fatness is the absence of correlation in body weight and fatness between adopted children and their adoptive families (Foch & McClearn, 1980; Price, 1987). Because of accessible adoption records in Denmark, researchers have been able to study biological and environmental contributions to children adopted at birth. In a study of 540 adult adoptees and their biologic parents, there was a strong relation between the weight class (thin, median, overweight, and obese) of the children and the BMI of their biologic parents ($p < 0.0001$), and there was no apparent relation between the children and adoptive parents (Stunkard, Foch & Hrubec, 1986).

Dietary Obesity

Twin and adoptive studies, and studies of Zucker fatties support a strong role of genes in development and maintenance of obesity in rats and humans. But there is laboratory evidence that long-term obesity can exist in animals having no apparent genetic predisposition toward obesity or in the absence of surgical or pharmacological treatment. Rats, mice, and dogs become obese on ad-lib diets that are high in fat (Blundell, 1987). When rats are given a variety of tasty foods, known as a "cafeteria diet," they eat more frequently, they eat larger amounts, and they gain a great deal of weight. Rolls, Rowe and Turner (1980) gave rats potato chips, cookies, crackers, and laboratory chow for 90 days and the rats were 95g heavier than ad-lib controls fed only chow. It is not necessary, however, to feed rats a varied diet to achieve weight gain; rats easily become obese when extra fat is added to their standard laboratory diet (Brownell, Greenwood, Stellar & Shrager, 1986; Faust, 1984; Keesey & Corbett, 1984).

A high-fat diet causes weight gain in humans as well as rats. One study showed that human subjects consuming large amounts of fat fail to compensate calorically over a two-week period. Lissner, Levitsky, Strupp, Kalkwarf and Roe (1987) fed 24 women of varying body fatness diets containing 15-20 percent, 30-35 percent, and 45-50 percent fat, with each diet consumed for two weeks during the six-week study. Subjects could eat as little or as much food as desired, but they ate no other food than that provided by the experimenters. As a result of change in fat levels, subjects ate an average of 600 more kcal/day on the high-fat diet than on the low-fat diet, and the excess was consistent throughout the two-week period. They lost a slight amount of weight on the low-fat diet and gained slightly on the high-fat diet. The Lissner et al. study indicates that there may not be adaptive responses to high-fat diets.

In summary, obesity generally occurs in laboratory rats as a result of VMH lesions, breeding Zucker fatties, or offering high-fat diets. There appears to be a genetic component causing at least some human obesities, and weight can easily be gained on a high-fat diet.

The Obese Plateau

If a laboratory rat is fed a high-calorie diet for a long time, eventually it will stop gaining weight. Weight stabilization at a high level is known as the "obese plateau." While it is possible that the obese animal may continue to eat large quantities of fattening food, it is also possible for it to maintain a higher weight even when returned to ordinary chow in amounts that previously maintained normal weight (Faust, 1984; Rolls et al., 1980). Faust (1984) says that calorie intake at the obese plateau is not significantly different from that of normal-weight control animals; however, diet may determine at which weight the plateau occurs.

Rats fed standard laboratory chow all their lives plateau at a much lower weight than rats fed a high-fat diet, and normal-weight rats reach a new, higher weight plateau when they are fed diets high in fat (Faust, 1984). Faust's rats became hypercellular after only three weeks on a high-fat diet and they therefore had larger-than-normal fat mass resulting in higher-than-normal weight plateau.

It is unknown why organisms generally plateau at one particular weight (Hernandez & Hoebel, 1980) and seem to defend that weight so tenaciously. For example, we don't know why one woman's weight may plateau at 200 lb, and another woman of similar age, height and bone structure may have a weight plateau at 240 lb. In any case, for most animals, body weight eventually stabilizes and intake seems to equal output.

Research has shown two possible reasons for the individual to stay in energy balance at a higher-than-normal weight: (1) she eats an excessive amount of food, but does not gain further because her body must expend larger-than-normal amounts of energy to maintain her oversize body, or (2) she eats normal amounts of food, but her body requires less energy than normal for maintenance and so her weight remains elevated.

Do the Obese Overeat?

It is difficult to know for certain how much obese people consume because most data have been gathered using methods that are not reliable or accurate. Researchers are divided on whether or not obese humans eat the same as or more than normal-weight humans. Eating data are collected either by recording intake as the subject goes along, or recalling what has been eaten over the past week or so. When subjects measure and record what they are about to eat, a method that is more precise than estimating what was eaten several days ago, it requires a great deal of effort and cooperation because every portion of food must be carefully itemized and weighed before the meal is enjoyed. If the subject is asked to recall what she ate over the past several days, much prodding may be required before she remembers everything consumed. Marr (1971) claims that some people can't recall what they ate beyond four days. When people are asked to recall only for 24-hour time periods, they may be quite accurate (Stunkard, Sorensen, Hanis, Teasdale, Chakraborty & Waxman, 1981), although the samples have been small and few in number. Bray, Zachary, Dahms, Atkinson and Oddie (1978) estimate the 24-hour recall has about 10 percent error, with most of the error found in the diaries of obese people who underestimate consumption by about 800 kcal per day.

Generally, normal-weight women seem to eat about 2200 kcal/day (Beaudoin & Mayer, 1953), but Beaudoin and Mayer found that recall records for obese women range from less than 1600 kcal to more than 2800 kcal, with consumption increasing as a function of the interviewer's skill and time spent in interview. This is similar to Gray's (1983) findings which revealed that repeated dietary histories taken on obese patients waiting for surgery showed a progressive increase in caloric intake with each assessment. Many obese subjects in Gray's study drank large amounts of high-calorie alcohol which substantially increases caloric consumption, although alcohol in the diet is often underreported.

In spite of these claims that the obese overeat, many researchers contend they eat no more, or even less, than normal-weight individuals. Bennett and Gurin (1982) say the obese eat about the same amount of food as normals; Woolley and Woolley (1984) also claim the obese do not overeat in comparison to others, and that it is possible for obesity to be maintained with normal or even undereating. Maxfield and Konishi (1966) found that obese women actually consume fewer calories than nonobese women.

Such conclusions are not surprising if one examines recall diaries of some obese women. Curtis and Bradfield (1971) studied six housewives for five weeks who were >20 percent overweight. Each woman kept a detailed diary of intake and output, with intake ranging from 1800-2250 kcal/day. Output was not always exact; one subject claimed to walk an hour a day, but when she was taken on a 45-min walk she became very fatigued. Her walks were, in fact, one-hour "social meanders." One wonders if the intake records were any more accurate. In another study, it was found that the obese accurately describe consumption at meals, but fail to accurately report snacks, frequently a high-calorie component in obese diets (Wurtman, 1987).

One problem that may make accurate recording of intake difficult for the obese is that they are not able to accurately estimate serving size. When subjects in Lansky and Brownell's (1982) study were asked to visually estimate portion sizes, they made errors as great at 46 percent, with the greatest errors made when estimating high-calorie foods.

When the obese are monitored by others, intake may be what is expected for their weight. Massively obese patients in a metabolic hospital ward ate about 5500 kcal/day (Bray et al.,1978), and obese boys ate considerably more food than their normal-weight brothers (Waxman & Stunkard, 1980).

A possible explanation for the varied reports on how much obese people eat is that when people are gaining weight--in other words, they have not reached their weight plateau--they may consume large amounts of food. But when weight gain stops, organisms may not eat much more than their normal-weight counterparts. This hypothesis is supported at least in the rat model. Faust (1984) fed lean Zucker rats a high-fat diet for a year and their weight rapidly increased. During the last several weeks of the study, their weight stabilized and caloric intake was no greater than that of lean controls. From this study, it is thus possible to speculate that some individuals can be extremely overweight and yet eat less than would be expected to maintain the weight.

Output

Metabolism

Output or expenditure consists of the following: (1) physical activity, including motion and posture maintenance, (2) processing nutrients and metabolites, (3) keeping warm, and (4) losses due to excretion (primarily fecal) (Booth, 1980).

Physiologists have been interested in metabolism since Antoine Lavoisier (1743-1794), a French chemist, who showed that animals generate heat in a manner similar to the combustion of burning substances (Gray, 1983). Lavoisier placed a fasting guinea pig in an insulated container which, today, would be called a "calorimeter," containing ice. He collected the carbon dioxide (CO_2) expelled by the animal and measured the amount of ice that melted during gas collection. Lavoisier burned a candle to produce the same amount of CO_2 that had been produced by the guinea pig. The amount of ice melted by the candle was similar to the amount of ice that had been melted by the animal, which showed that combustion outside the body is similar to the burning or metabolic process inside the body. Lavoisier's contributions to science did not save him from the guillotine, but they are still valid today, although the procedures for measuring total energy expenditure (TEE) are somewhat more advanced.

Measuring Metabolism

There are two primary methods for measuring TEE: direct and indirect calorimetry. Direct calorimetry measures a person's TEE when enclosed inside a sealed chamber, and body heat output is measured directly. Animals, including people, can live for several days inside calorimeters, or respiration chambers, which are similar. This measurement method is precise, but is very costly, is inconvenient for the subject, and does not capture the subject's typical behavior.

Indirect calorimetry measures oxygen consumption and production of CO_2 from respiration (Gray, 1983), which is converted into heat equivalents by mathematical formula. Apparatus for indirect calorimetry are portable, fairly inexpensive and can be used while the subject performs a variety of activities. Ventilated hood systems are placed over the head and collect expired air, and even less cumbersome is the Douglas bag which has a noseclip and mouthpiece into which the subject breathes, although slight error occurs with this method (Garrow, 1978). Unfortunately, none of these methods is practical for long-term use because the equipment interferes with normal routine.

How does the body's regulating mechanism "know" what level metabolism should be in order to maintain the organism in energy balance? Kleiber (1975) has proposed that the mean standard metabolic rate in mammals is 70 times the three-fourth power of their body weight in kilograms. This formula estimates metabolic output per day for an animal in a fasting, resting state, and is known as basal metabolism (BMR). A person weighing 70 kg (about 154 lb) would have a daily basal metabolic rate of approximately 1700 kcal. A 120-lb person would have a daily BMR of 1400 kcal, while a 200-lb person would have a daily BMR of 2060 kcal. Kleiber measured metabolisms on 26 species of mammal and the relationship held across all species.

Metabolism in the Obese

Very little of the extra energy expenditure in the obese is due to moving extra weight around -- it is only about 8 percent of the extra output (Ravussin, Burnand, Schutz & Jéquier, 1982). The remainder of the excess expenditure is due to a higher resting metabolic rate. Resting metabolism is the "total energy required by the body in a resting state" (Gray, 1983), and therefore energy expenditure is determined, for the most part, by "the cost of resting metabolism" (Garrow, 1978). Metabolism is believed to increase as a function of the size of lean body mass (Garrow, 1978; Ravussin, et al., 1982) and as animals increase body fat as a result of weight gain, they also increase the amount of fat-free tissue, thereby increasing metabolic rate (Garrow, 1986). Metabolism in women is, on average, 10-15 percent lower than in men (Brownell, Rubin & Smoller, 1986; Garrow, 1978), because women have less muscle and more fat than men.

Set Point

Energy is brought into the body in the form of food and is measured in calories. A calorie is a unit of heat, specifically the amount of heat required to raise the temperature of 1g water from 14.5C to 15.5C (Kleiber, 1975). The more calories consumed by an organism, the more potential energy the organism has. If the available energy is not used either by metabolic or physical activity, it is stored for later use, either as glycogen in short-term storage, or as fat in long-term storage.

One manifestation of energy storage is weight gain, which is usually small and gradual (Garrow, 1978), and probably occurs because of small caloric or exercise imbalance over a period of months or years. If a person eats 10 extra kcal/day, about one pound will be gained in a year. In ten years, the person will be 10 lb heavier, and this is a common weight gain in adults over a decade or two.

How can organisms regulate intake and output so precisely? People generally don't count calories very well, and caloric intake may often be erratic. Women in Curtis and Bradfield's (1971) study did not consume the same amount of food on weekends as they did during the week, and the discrepancy was as much as 500 or more kcal/day. Apparently, and up to some limit, the metabolism adjusts to compensate for short-term caloric changes. When organisms overeat, metabolism rises. If overeating is sufficient, weight gain occurs, but the effects of overnutrition are blunted by the increased metabolism (Keesey & Corbett, 1984). Conversely, and most important in obesity research, is the fact that metabolism compensates in both directions. When the organism consumes less than necessary to maintain body weight, the metabolism slows down, thereby blunting the effect of starvation.

The lability of metabolism in the presence of conditions threatening body weight suggests an internal regulator or "set-point" mechanism that prevents weight from fluctuating. This tendency to maintain an organism in a state of internal stability is known as "homeostasis" and is, by definition, due to coordinated responses of internal systems to internal and external stimuli.* In order to maintain precise body weight, the set-point mechanism must integrate internal and external stimuli and thereby control both metabolic processes and feeding (Hernandez & Hoebel, 1980).

There is much evidence supporting the set-point theory of weight regulation. Keesey (1980) notes that the average white American male's weight changes only about 4-5 lb between ages 30 and 60; Garrow (1978) says that adult men and women's weights fluctuate about 22 lb; Hervey (1969) cites research indicating women gain about 24 lb between ages 25-65. These weight changes are, at most, less than one-half pound/year, and while female weights are more labile, the changes are too gradual to be attributable to chance alone.

Defense of Set Point. When people volunteer to gain weight (Salans et al., 1971) or lose weight (Keys, Brozek, Henschel, Mickelsen & Taylor, 1950), once they resume normal eating, weight quickly returns to normal. In an experiment studying the effects of starvation, male volunteers lost an average of 24 percent body weight (Keys et al., 1950). During starvation, metabolisms were reduced an average of 40 percent; during rehabilitation, metabolisms became extremely high, much higher than at prestarvation levels, a phenomenon called "luxusconsumption," or "cost of growth."

Metabolic defense of weight occurs as well when weight is elevated above normal. Whether an individual is normal weight or overweight, caloric restriction in dieting usually produces a decrease in metabolism that ranges from 15-30 percent (Brownell & Stunkard, 1980). This decrease is much greater than would

*Webster's New World Dictionary (1970). New York: World Publishing Company.

be expected from the amount of weight lost and is more pronounced in individuals restricting intake to 800 kcal/day or less (Gray, 1983). The phenomenon is also noted in rats, in which rate of energy expenditure declines more quickly than body weight. Keesey and Corbett (1984) found a weight loss in rats of 5.8 percent was accompanied by a decline in RMR of 14.7 percent. This is almost identical to the 15 percent reduction in expenditure found by Bray (1969) in grossly obese women after losing about a pound/day for 24 days on a very low calorie (VLC) diet.

What is especially unfortunate about this increased metabolic efficiency in the face of reduced caloric intake is that the metabolism remains lowered even after the desired weight is reached and the dieter begins eating normally for the new weight. Similarly, when a formerly overweight laboratory rat is fed a normal ration after reaching normal weight, it will regain most of the lost weight (Booth, 1980). This indicates that the rats adapted to severe caloric restriction by reducing maintenance requirements and "thereby increasing the efficiency of food utilization . . . " and this increased efficiency is proportional to the degree of caloric deficit.

It thus seems "inexorable" that obese people who lose considerable weight should regain the lost weight even when remaining on a moderate diet (Garrow, 1983). When obese people lose weight, they are trying to live at a weight level below their personal level of regulation. Garrow (1983) says that if "a 200-pound woman acts as if she were underweight, perhaps she is, in fact, underweight relative to some higher weight level at which she would eat normally." It may be possible, however, that just as her set point was raised after some period of positive energy balance, it could be lowered if she can maintain a long-term reduction in body weight (Garrow, 1978). Metabolism apparently does not pass judgment on what weight is best; it defends whatever weight the organism maintains over a long time. Only when some powerful internal or external threat occurs to the homeostatic mechanism, does the set point, with apparent reluctance, change.

Set-Point Change. Change in set point may occur according to catastrophe theory (Stewart, 1983). The theory may show how smooth changes in an independent variable (food consumption) can lead to sudden changes in a dependent variable (body weight). This could explain why weight sometimes suddenly jumps as a result of a steady increase or decrease in food consumption. In other words, catastrophe theory "begins where functional relationships break down." Disproportionate intake may occur in organisms who are either extremely sedentary or are exhausted from prolonged exercise, in which case intake may not correspond to output (Bullen, Reed & Mayer, 1964).

Mayer, Purnima and Mitra (1956) found that workers in a Bengalese jute mill increased caloric intake as a function of increasing expenditure requirements of various jobs, with the exception of very sedentary workers who ate as many calories as workers in physically demanding jobs (blacksmiths, cutters and carriers). Mayer et al. conclude that there is a positive correlation between food intake and activity level, but only within the "normal activity range." When an organism becomes extremely sedentary, food intake does not decrease, rather, it increases. These data suggest that organisms who are inactive over some length of time may raise their set point to a higher level.

Short-Term Energy Regulation

Except for these perturbations of weight, organisms remain in homeostasis and, by definition, intake must equal output (Booth, 1980; Keesey, 1980). Over some time period, at least several days, intake seems to equal output in most humans; however, on a day-to-day basis, there are wide fluctuations between caloric consumption and energy expenditure (Garrow, 1978; Hervey, 1969; Titchenal, 1988). Durnin (1961) used indirect calorimetry to measure output in men and women, including housewives, clerical workers, students, military cadets and coal miners. Intake was measured by individual inventory. There was no correlation between same-day intake and output for 59 of the 69 subjects, although for 41 subjects, intake and output balanced out over a seven-day period. Edholm, Fletcher, Widdowson and McCance (1955) studied 12 military cadets for two weeks and found no correlation between daily intake and output for any of the subjects, but there was a significant correlation between mean daily output and intake that was two days later. Over a several-month period, body weights for 11 of the 12 subjects "moved in the direction to be expected from their energy balance."

These studies indicate there is no momentary or short-term energy regulation for most, but not all, people. Ten subjects in Durnin's (1961) study showed some significant same-day correlation between intake and output, and others showed no correlation within a seven-day period. Apparently, time between intake and compensatory output varies between individuals but, sooner or later, intake and output usually equal each other. Near equality of energy over long periods does not "come about by chance" (Hervey, 1969).

Other researchers contend that the constancy of a "supposedly regulated variable" is exaggerated (Booth, 1980), and that some people's weight varies by many pounds between weighings. Booth says that energy balance does not exist even as long as a few weeks, let alone several months or years. Bennett and Gurin (1982) question the existence of a set point because no one has discovered the mechanism; and Garrow (1978) simply says the set point does not exist.

Metabolism and Aging

Many individuals gain weight as they age (Booth, 1980). In the Rissanen et al. study (1988) of 17,000 Finns, for example, average weight for men increased until the fourth decade; women gained weight until the sixth decade. Obesity was increasingly common in successive age cohorts in both men and women until the seventh decade.

Increasing obesity over time corresponds to decreasing metabolism with age. Metabolism is highest in infants and gradually declines throughout childhood. After age 18, metabolism declines about 2 percent per decade (Gray, 1983), although Bennett and Gurin (1982) estimate metabolic decline as much as 5 percent per decade after age 30. It is unknown if this decline is a result of generalized decrease in energy expenditure with increasing age, or if the decline is a part of the aging process itself. In either case, slight decreases in metabolism over time may slowly drive weight upward, if this metabolic decrease is not accompanied by increased exercise. Because an effect of exercise is to increase rate of energy expenditure (Brownell & Foreyt, 1985; Brownell & Stunkard, 1980; Epstein & Wing,1980; Gray, 1983), maintaining an exercise regimen throughout life may offset metabolic decline due to aging.

Exercise

This section will explore research on physical activity as an important component of energy expenditure. Physical activity can be further divided into the work we perform in our occupations, and leisure-time pursuits (Montoye & Taylor, 1984). Both kinds of activity have been researched, including their relationship to the promotion and maintenance of normal weight.

During the 1970s behavior modification, in the form of eating management and stimulus control, seemed to be the answer for successful weight loss and maintenance, and there was "surprisingly" little attention paid to exercise as a component in weight-reduction programs (Martin & Dubbert, 1982). In the 1980s confidence in stimulus control and eating management for significant weight loss and maintenance had waned, and exercise became an important adjunct to behavior therapy in the prevention and treatment of obesity (Segal & Pi-Sunyer, 1989).

Exercise is probably attractive to behavior therapists because it is amenable to contingency manipulation. Furthermore, it is possible that exercise facilitates weight loss by increasing basal metabolic rate (Brownell & Foreyt, 1985; Perri, McAdoo, McAllister, Laver & Yancey, 1986), which may counteract the slowing of metabolism that accompanies reduced caloric intake. Although TEE is primarily determined by the cost of resting metabolism, exercise plays an important role in raising metabolic output and subsequent TEE, so it is advantageous for the overweight person to explore exercise treatment for weight loss.

Metabolic Effects of Exercise

Data describing the effects of exercise on resting metabolism are equivocal; in two similar studies, one consisting of four males and four females (Maehlum, Grandmontage, Newsholme & Sejersted, 1986) the other consisting of six males (Bahr, Ingnes, Vaage, Sejersted & Newsholme, 1987), subjects exercised to 70 percent of their maximum aerobic capacity (VO_{2max}). Oxygen uptake was then measured frequently for the following 24 hr while in a resting state. Throughout the first 12 hr of measurement, uptake was significantly greater for exercising subjects than for nonexercising controls. Subjects in the Bahr et al. study had an excess uptake that was proportional to the duration of exercise (either 20, 40 or 80 min), indicating that length of expenditure at VO_{2max} determines magnitude of post-exercise uptake.

In contrast, Segal and Pi-Sunyer (1989) found that the elevation in resting metabolism over 3 hr following 30 min of moderate-intensity exercise amounted to about 14 kcal, certainly a trivial amount, although they claim that exercise has an important effect on rate of expenditure during the actual engagement of exercise. Similarly, Titchenal (1988) questions whether or not frequent exercise increases overall metabolism, and it may not prevent the decline of metabolism when exercise is combined with a low-calorie diet (Donahoe and Heber, 1987). In summary, energy expenditure is increased during exercise, but post-exercise effects on metabolism seem to be unclear at this time.

Measuring Activity

It is very difficult to measure activity throughout a typical day (LeBow, 1977) because it is a continuous but variable function, dependent on the nature and intensity of the activity, time after eating, and other environmental conditions (Acheson, Campbell, Edholm, Miller & Stock, 1980). It is especially difficult to observe subjects during leisure time because activities may frequently change (Montoye & Taylor, 1984). Time-motion studies are time consuming and very costly; while diaries of physical activity require extensive cooperation from the subject (Brownell & Stunkard, 1980) and are subject to the same error sources as diet recalls.

Activity Surveys

As a result of problems encountered with activity diaries (or logs), tests have been devised to simplify activity estimation. A commonly used test of energy expenditure is the Minnesota Leisure Time Physical Activity Questionnaire (MLTPA) (Taylor, Jacobs, Schucker, Knudsen, Leon & Debacker, 1978). A list of activities with caloric equivalents was compiled from middle-aged, middle-class American men living in Minnesota and, while the list of activities covered is long, many activities not on the questionnaire are carried out by other populations, for example, housewives. Montoye and Taylor (1984) criticize the MLTPA because the questionnaire requires detailed data on frequency and duration of activity over a full year, a demand on remembering that is too great. Further, the test-retest correlation coefficients show many activities with correlations that are unacceptably low. Although the questionnaire is suitable for estimating leisure time activity of large groups, it is not a reliable instrument for characterizing individual activity because of large within-individual variability (Montoye & Taylor, 1984).

The Paffenbarger Survey (Paffenbarger, Wing, & Hyde, 1978) converts activity into calories expended in a typical week by asking respondents to estimate flights of stairs climbed and blocks walked per day, and number of hours spent each week participating in sports. The Survey has correlated well with portable activity monitors (Cauley, LaPorte, Sandler, Bayles, Petrini & Slemenda, 1984), and is a good predictor of risk for CHD in middle-aged males (Paffenbarger et al., 1978).

Mechanical Activity Monitors

Researchers have made many attempts to determine how much walking people do throughout their lives. Walking is of interest because it is a universal, frequently occurring behavior and is the major method of locomotion in humans; however, calculating how much walking an individual performs has presented "considerable problems" (Marsden & Montgomery, 1972). Because the method used for data collection should be convenient and unobtrusive, pedometers have traditionally been used to measure number of steps taken by people during a specified time period. Although there are many brands of pedometer, all of those tested have proven to be notoriously inconsistent. Marsden and Montgomery found up to a 50 percent discrepancy between pedometers on the same individual; and Gayle, Montoye and Philpot (1977) tested pedometers on subjects walking equal distances under identical conditions and found a reproducibility error of 11 percent due to the mechanical imprecision of the instrument.

Researchers have attempted to devise instrumentation that is more accurate than pedometers; for example, Marsden and Montgomery (1972) built a battery-powered counter with a switch that was operated by body weight. The switch was fitted into the insole of the shoe and was connected by wires to the counter that was carried in the pocket.

A more sophisticated instrument than either the pedometer or the battery-operated counter is the electronic motion sensor. A type of sensor is the Large-Scale Integrated Motor Activity Monitor (LSI), which measures quantity of movement. Inside the monitor is a cylinder containing a ball of mercury and a switch. A slight rotation of the unit causes the ball to roll down a cylinder and contact the switch, with the number of switch closures recorded on a magnetically activated display. The LSI units have shown low variability between units and they seem to measure movement with accuracy across time (LaPorte, Montoye & Caspersen, 1985). The main problem with the LSI is that it does not differentiate between different intensities of movement.

Another kind of sensor, the accelerometer, measures both quantity and intensity of movement. Accelerometers can provide sufficient information to define movement of a part of the body (Morris, 1973); however, they are unable to respond to isometric (static) forms of activity (Balogun, Amusa &

Onyewadume, 1988), and it is unknown how well they perform when individuals engage in a combination of isometric and isotonic (aerobic or dynamic) exercise.

A commonly used accelerometer is the Caltrac Personal Activity Computer® (Hemokinetics, Inc., Madison, Wisconsin), which utilizes a small electronic accelerometer to detect motion and acceleration by a piezoelectric bender element (Williams, Klesges, Hanson & Eck, 1989). The device allows the experimenter to measure calories expended by combining basal metabolic rate (BMR) and activity level; or either BMR or activity level alone. There have been few field studies of the Caltrac and, while it has demonstrated excellent short-term reproducibility ($r = 0.94$) when monitored during laboratory trials (Montoye, Washburn, Servais, Ertl, Webster & Nagle, 1983), two studies have indicated problems with validity (Nichols, Patterson & Early, 1990) and reliability (Williams et al, 1989).

Energy Expenditure in the Overweight

Although motion sensors have not been used to compare activity in people of varying weight, it appears that the obese expend less energy than normal-weight people, although the obese have increased metabolic output and they use more energy for locomotion (Gray, 1983). In Bloom and Eidex's (1967) study, obese and lean adults wore a device measuring the amount of time they spent sitting and standing. The obese spent an average of 21.7 percent, or 5.2 hr per day, standing, while the rest of the time was spent sitting or lying down. In contrast, normal-weight subjects spent 36 percent, or 8.6 hr per day, standing. Furthermore, the obese spent about 65 min per day longer in bed than the nonobese, leading Bloom and Eidex to conclude that the obese may as well have spent three-fourths of their lives in bed.

Bullen, Reed and Mayer (1964) observed that obese teenage girls at a summer weight-loss camp were much less active than their normal-weight peers. At any one time, only 9 percent of obese girls, filmed during various sports activities, were active, compared with 55 percent of their nonobese counterparts. In swimming, the obese girls were less than one-half as active as nonobese girls, and in tennis, they were considerably less active. The obese girls were classified as inactive even during the activity periods.

When obese and nonobese men and women wore pedometers continuously for one or two weeks (Chirico & Stunkard, 1960), the difference between obese and nonobese women was "striking and unequivocal"; the obese women were considerably less active than the nonobese women. Many of the obese women walked less than 2 miles a day, a distance shorter than any of the nonobese controls. The differences between the obese and nonobese men were not as clear, but Chirico and Stunkard conclude that the physical activity of many obese women is so severely limited that even small increases in activity might promote weight loss over time. These results are supported by Lewis, Haskell, Wood, Manoogian, Bailey and Pereira (1976) who note that overweight middle-aged women are, in general, sedentary.

There are data indicating that obese men are also more sedentary than nonobese men. Sopko, Jacobs and Taylor (1984) found that obese and nonobese men ate about the same number of calories a day, but the more overweight the man, the less he exercised. Sopko et al. conclude that it is the amount of expenditure over time that leads to and maintains fatness.

A few studies contradict the above conclusions and bring into question the effect of exercise on obesity. In one study (Tryon, 1987), obese and nonobese men and women wore a motion recorder for two consecutive weeks. The data indicated that all groups of subjects were about equally active, with little variation about the grand mean. When 50 obese and nonobese women wore pedometers for 48 hours, Maxfield and Konishi (1966) found no difference in overall activity levels between the two groups. Finally, Baecke, van Staveren and Burema (1983) found that obese and nonobese women were equally active according to activity questionnaires completed by both groups.

Exercise in Obese Children

The role of activity in obese and nonobese persons in the development of human obesity is therefore not yet clear, but overall evidence suggests that obese adults are probably less active than normal-weight adults (Brownell & Stunkard, 1980). The results for children, however, indicate that some obese children are as active as their nonobese peers. The obese boys observed by Waxman and Stunkard (1980) were far less active than their normal-weight brothers in the home, somewhat less active outside the home, and equally as active as the normal-weight brother at school. Although the obese boys expended less energy than their brothers as far as physical movement was concerned, the extra expenditure of calories necessary to move their heavier bodies elevated their metabolisms, resulting in an increase in energy expenditure beyond that of the normal-weight brothers.

An important factor mediating fatness in children in the western culture is the television set (Foreyt, 1987). There is a significant association between time spent watching television and the prevalence of obesity. In children between 12 and 17 years old, obesity increases by 2 percent for each additional hour of daily television viewing, during which time, the child is not performing more rigorous activity that might help maintain normal weight.

Exercising to Lose Fat

As a result of physical training, lean body mass increases while fat decreases (Brownell & Stunkard, 1980; Katch & Katch, 1988; Stern, 1984; Wilmore, 1983). The main effect of exercise during a diet may be to preserve lean body mass and increase the reduction of body fat that occurs with reduced caloric consumption. Exercise protects the individual against the loss of the fat-free weight that occurs from diet alone (Oscai, 1973). Therefore, most people may not be able to lose weight successfully without engaging in regular exercise.

Epstein and Wing (1980) performed a meta-analysis on exercise studies with male subjects and found that people in exercise groups lost an average of 0.2 lb per week; when only overweight subjects were analyzed, weight loss was 0.3 lb per week. There is research, however, indicating that exercise alone leads to greater weight loss than noted by Epstein and Wing. When college women expended 500 extra calories a day in walking and jogging (Moody, Kollias & Buskirk, 1969), subjects lost an average of 1.5 lb per week without dieting.

The primary reason little weight is lost when an exercise regimen is not accompanied by reduced intake is that little extra energy is needed for performing very rigorous exercise (Björntorp, 1978). The Vasaloppet, for example, is an 85-km ski race in Sweden that takes about 10 hr for a nonprofessional athlete to complete. If we assume the skier eats nothing during the day of the race, the loss of calories will still be less than 1 kg (2.2 lb) of adipose tissue.

Health Benefits from Exercise

While immediate effects of exercise are limited, the important result of exercise is the cumulative effect that small increases in physical activity may have over the long run (Brownell & Stunkard, 1980). Brownell and Steen (1987) have said that any amount of physical activity is better than none, with the main benefit of exercise accruing from its chronicity (Brownell & Foreyt, 1985). This may be especially true for people at risk for CHD, because increased physical activity has been associated with reduced CHD risk (Brownell & Stunkard, 1980; Cauley et al, 1984; Kentala, 1972; Paffenbarger et al., 1978; Segal & Pi-Sunyer, 1989). In general, the circulatory and respiratory systems benefit from exercise (Björntorp, 1978), and patients who exercised following myocardial infarction had significantly improved functional capacity five months after the heart attack over patients who failed to participate in frequent exercise, although there was no effect on mortality (Kentala, 1972).

Maximal heart rate decreases with age, but older people can train rigorously, and it is not necessary for a person to maintain conditioning throughout the lifespan in order to engage in strenuous activity when old. Sedentary men aged 56-70 increased maximal oxygen uptake between 9 and 14 percent following eight weeks' endurance training (Suominen, Heikkinen, Liesen, Michel & Hollmann, 1977), an increase that is comparable in younger men following similar training. Older exercising women can also have aerobic capacity and body composition similar to that of much younger, sedentary women (O'Toole & Douglas, 1988). Older people who are fit can perform endurance feats that require a well-conditioned body; for example, the Hawaiian Ironman Triathlon, a contest that takes from 9 to 17 hours to complete, each year includes several finishers over 60 years of age.

After the age of about 35 years, women begin to lose bone at the rate of .75 to 1 percent per year (Smith, 1981). As a result of this bone involution, hundreds of thousands of women fracture their hips each year with a 50 percent chance of mortality for any one accident. One of the major factors in bone loss is inadequate physical activity, but exercise may retard or reverse the normal loss of bone mineral content. Athletes engaged in weight-bearing exercise have shown up to 40 percent increase in bone mass (O'Toole & Douglas, 1988).

Another benefit of exercise for women is that those who exercise regularly are more likely to be more comfortable with day-to-day exertion, have reduced anxiety and an improved body image (O'Toole & Douglas, 1988). In general, there seems to be an enhanced quality of life for women who maintain a routine of regular exercise, and it is apparent that physical activity has beneficial effects even in the absence of changes in body weight (Brownell & Stunkard, 1980).

Exercise Adherence

Activity and Appetite

Many women say they do not exercise because it is commonly believed that strenuous activity will increase hunger (Colvin & Olson, 1983). In fact, exercise may decrease the appetite (Brownell & Stunkard, 1980), although the relationship between activity and appetite is affected by gender, the intensity of the exercise, and body weight. For example, there is a strong sexual dimorphism in rats: female rats often eat more when they exercise (Stern, 1984; Titchenal, 1988) and either maintain or gain weight, while male rats decrease intake and lose weight (Pi-Sunyer, 1987).

Exercise can stimulate the appetite if it is strenuous and over extended periods of time. Farm laborers and lumberjacks consume more calories than more sedentary people; Oscai (1973) documented intake in five Finnish lumberjacks who consumed an average of 4763 kcal per day, double the normal intake of a sedentary individual. If the exercise is less strenuous, perhaps on the level typical of a person trying to lose weight, calorie intake may increase temporarily and then gradually decrease below intake at the inception of the exercise regimen. Leon, Conrad, Hunninghake and Serfass (1979) studied ten overweight young men who expended an extra 1000 kcal a day working on a treadmill for 16 weeks. At the beginning of the study, average daily Calorie intake was 2288, which increased to 2584 kcal per day after four weeks of exercise, and decreased to 2149 kcal per day by the 16th week. This study suggests that long-term moderate exercise may eventually decrease appetite, while a short-term increase in energy expenditure may have little effect on overall caloric intake (Thompson, Jarvie, Lahey & Cureton, 1982).

Exercise and Self Control

Probably the most significant problem resulting from exercise treatment for obesity is adherence. Patients join treatment groups with an enthusiasm which quickly dissipates, and dropout soon follows. This may occur because exercise is often difficult and tedious, and weight loss is small compared to the commitment that must be made to the program. Obese patients cite many reasons for poor adherence, including discomfort, boredom, embarrassment, and inability to schedule regular sessions (Brownell & Stunkard, 1980).

Long-term effects of regular exercise are distant in time, while the rewards for not exercising are immediate. When a person performs an activity that is momentarily unpleasant but has eventual benefits, that person is said to have self-control. According to the Ainslie-Rachlin theory of self-control (Fig. 2), a small immediate reinforcer can be more desirable than a large, delayed reinforcer if the value of the reinforcer decreases hyperbolically with increasing temporal distance from the reinforcer (Ainslie, 1974; Rachlin, 1974).

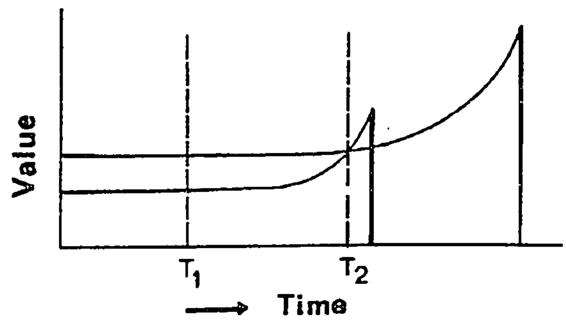

Figure 2. Ainslie-Rachlin Model of Self Control. Value of the Reinforcer Increases with Decreasing Temporal Distance.

At T_1 the organism will choose the larger, delayed reinforcer because both reinforcers are some time away. At T_2, the smaller reinforcer is at hand, while the larger reinforcer is temporally farther away. At this point, the organism will choose the smaller, more immediate reinforcer. The model shows that both impulsivity and self control cannot be chosen simultaneously because they are mutually exclusive and, thus, only one outcome can be chosen. The model also shows that choice between two reinforcers is determined by their respective values. The relative value of a reinforcer is defined by Baum and Rachlin (1969) as the product of the ratio of reinforcement amount, rate, and immediacy for two alternatives. The value of a reinforcer can also be measured by the amount of time an organism spends working for the reinforcer. This can be shown in the following equation:

$$T_1 / T_2 = V_1 / V_2 = A_1\ r_1\ I_1 / A_2\ r_2\ I_2$$

where A is the amount of reinforcement given, r is the number of presentations of the reinforcer, and I is the immediacy of the reinforcer. If the term immediacy is changed to the reciprocal of delay, the equation becomes:

$$T_1 / T_2 = V_1 / V_2 = A_1\ r_1\ D_2 / A_2\ r_2\ D_1$$

If exercise is considered in relation to the Ainslie-Rachlin model, it could be said that a person who exercises is given a choice between avoiding the discomfort of exercise, a small immediate reinforcer; and better health, a larger, delayed reinforcer. According to the model, the choice will be for better health only when the opportunity to avoid discomfort is some temporal distance away, and the individual will choose to remain inactive as the occasion for discomfort becomes imminent. The Ainslie-Rachlin model has not been tested with exercise as an independent variable; however, it has been tested extensively in the laboratory with pigeons pecking for food, with the choice between a small, immediate food reinforcer and a larger, delayed food reinforcer (Ainslie, 1974; Grosch & Neuringer, 1981; Logue, Chavarro, Rachlin & Reeder, 1988; Logue & Peña-Correal, 1985; Mazur & Logue, 1978).

Because weight-loss benefits from exercise are not immediate, it is difficult to persuade the overweight person to begin doing something on a regular basis that may be intensely disliked. That the obese are less active than nonobese people is a good indicator that they eschew activity.

Attrition

It has been estimated that attrition in a supervised exercise program is about 50 percent within 6 months of initial involvement (Dishman, 1981); even after a person has suffered from myocardial infarction, eventual fading of exercise therapy is common (Björntorp, 1978; Kentala, 1972; Martin & Dubbert, 1982). Maintenance of exercise after weight loss is also poor (Perri et al., 1986).

There is little experimental research on exercise adherence (Martin & Dubbert, 1982), and researchers have had difficulty defining when an individual is or is not adhering to a regimen. One way to define adherence is to set a criterion for minimum participation within some predetermined range, and subjects can then be rewarded for meeting the criterion. Epstein and Wing (1980) used contracts or lotteries for attendance in an aerobics program for normal-weight college women. Both groups had high attendance levels that were significantly greater than for control subjects who did not participate in contracting or the lottery. The authors suggest that lotteries may be very good for maintaining behavior that is already acquired because the reinforcer is delivered probabilistically on a variable-ratio schedule in relation to the responses that have already been established.

Because motivation to exercise is acquired (Booth, 1980), it is possible for researchers to use techniques such as contracts and lotteries to encourage subjects to begin and maintain exercise. In fact, it may be less difficult to increase exercise than it is to change dietary habits (Lewis et al., 1976).

Exercise Tailored to the Individual

It is very difficult to find an exercise regimen that is appropriate for a particular individual, especially if that individual is obese (Brownell & Stunkard, 1980). The more intense and frequent the activity, the less likely an obese person will be able to perform and maintain the routine. Most researchers advocate aerobic exercise (Epstein & Wing, 1980) because it has a relatively high caloric expenditure, can be performed with others, is low cost and has low risk. Such activities include walking, jogging, swimming and bicycling. Walking is perhaps the easiest way to burn calories and lose weight, although the results are slow and take time.

Walking may be one of the few aerobic exercises that is acceptable to most obese people, and it can be added to daily routine without difficulty. Brownell and Stunkard (1980) point out that there are two kinds of activity: programmed and routine. Programmed activities are regularly scheduled sessions of exercise, while routine activity is the day-to-day exercise engaged in by all individuals, such as walking, standing, using stairs, moving objects, and so forth. Most exercise programs stress planned activities, such as walking, aerobics and jogging, which take up a very small portion of one's life, even when the individual is committed to exercise.

There is a need for studies exploring ways for people to increase routine activity, thereby incorporating exercise into daily life, rather than making exercise something that is separate and discrete from one's normal routine. Brownell and Jeffery (1987) state that people should be encouraged to use stairs instead of an elevator, to walk short distances instead of driving, to park the car farther away from one's destination, and to try other environmental manipulations that impel the individual to move around more. Examples include keeping the telephone in a remote part of the house, rather than having extensions in several rooms; or acquiring a pet that needs frequent exercise.

The incorporation of additional activity in one's routine may be best for the obese person, although various kinds of anaerobic exercise should be explored. For example, people who play tennis on a regular basis typically have less body fat and more lean body mass than sedentary controls who may be several years younger. A survey of 50 men and women between 31 and 55 years of age who played tennis from 9.7 to 11.1 hr/week (Vodak, Savin, Haskell & Wood, 1980) showed unequivocal physical benefits. Most of the players had not taken up the game until age 30 and were class B or C players. All players were lean in that the men had only slightly more relative body fat than 133 untrained college-age men (16.3 vs. 14.5 percent), and the women players had less body fat than 128 untrained college-age women (20.3 vs. 25.7 percent).

Other anaerobic activities that are enjoyed by many people include dancing, fencing, soccer, and other team sports that, when engaged in regularly, burn up a considerable number of calories. Short bursts of exercise also can have eventual salutary effects on overweight individuals. Substituting going up and down two flights of stairs each day instead of taking an elevator amounts to 6-12 lb a year weight loss.

Because our society is geared toward saving labor, it is difficult for people to perform behaviors that waste energy (LeBow, 1977), or to waste energy performing routine activities; for example, most people eschew stairs for elevators and escalators. Brownell, Stunkard and Albaum (1980) made more than 21,000 observations of people in public places who had a choice between stairs and an escalator. Nonobese young males were most likely to use the stairs, and obese men and women were least likely to use stairs. When Brownell et al. posted a public sign reminding people that exercise is good for one's health, stair use increased. A particular advantage in stair use is that the caloric expense of climbing stairs is higher than for many vigorous activities such as running, swimming and calisthenics (Brownell & Stunkard, 1980), and the energy expenditure is a function of body weight. Further, the opportunity to use stairs is usually available and the behavior can be easily incorporated into daily life.

Unless the activity program is rigorous, however, the effects of exercise on weight will be slow and probably discouraging unless dietary restriction is incorporated into the program. People who engage in extremely labor-intensive occupations burn fewer calories than might be expected (Garrow, 1978); for example, an average person performing heavy labor burns up approximately 800 more kcal/day than a sedentary worker. One must keep in mind that the expenditure attributable to exercise is only that amount that would not be expended if one were sedentary. A two-hour walk burning 600 kcal is the gross cost of exercise, while the net cost is considerably less (Garrow, 1978).

The effects of increasing exercise are not worth the effort to most people. Those most in need of exercise are probably least likely to engage in a long-term program and, if they begin, are likely to quit. Perhaps it is time to view exercise as something other than a limited number of activities, such as aerobics, jogging and walking. Considerable caloric expenditure occurs during such diverse activities as tap dancing, yoga, rock climbing, and horseback riding. Once people explore alternative activities, many may find a rewarding pastime that also happens to improve health and facilitate weight loss.

Behavioral Differences in Normal-Weight and Overweight People

The present review has cited research supporting primarily two independent, but not necessarily opposing, views of what causes and maintains obesity. One view shows that some obesities are genetic (Nisbett, 1972; Stunkard et al., 1986; Foch & McClearn, 1980; Keesey, 1980; Hoebel, 1984; Keesey & Corbett, 1984), with the Zucker fatty an example of obesity bred in rats from lean heterozygous pairs. The second view of obesity is that it can occur, permanently, in normal-weight rats following a long-term diet of good-tasting, high-fat food (Blundell, 1984; Rolls & Rowe, 1980). Because no genetic marker has been found for human obesity, conclusions on genetic obesity in humans are presently tentative. It would seem that there is a strong genetic component in human obesity based on correlations between monozygotic twins in Stunkard et al.'s (1986) study of 4000 twin pairs; however, there was a decreasing correlation within twin pairs over a 25-year period, which supports the existence of an environmental influence on obesity. Thus, it can be inferred that human obesity is partly determined by the environment in which one lives.

Even if an individual is predisposed to fatness, it should be possible to reduce obesity if overweight people *behave* similarly to slender individuals. Little research has examined lifestyles of thin people; however, if we examine the two components of lifestyle that strongly affect body weight--exercise and eating--some comparisons can be made between normal-weight and overweight people.

Exercise

Exercise in Young Rats

For the most part, there is evidence that lack of exercise promotes obesity in young rats. Exercise in early life maintains lower body weight in male rats than in sedentary controls, even though both groups ate the same amount of food (Oscai, Babirak, Duback, McGarr & Spirakis, 1974). This effect lasted for at least nine months after exercise termination (subjects were sacrificed at 62 weeks); however, exercise seems to be of little help in preventing obesity in the Zucker fatty. Deb and Martin (1975) exercised weaned fatties for 11 weeks and they contained 28 percent body fat compared to 6 percent in sedentary Zucker lean rats. The nonexercising Zucker fatties were even fatter, with 39 percent body fat. Exercise seems to be able only to stem the inevitable outcome of obesity (see Sjöström, 1980).

Activity in Normal-Weight vs. Overweight People

There is considerable support for the contention that overweight people are as active as normal-weight people; and there is considerable support for the contention that overweight people are significantly less active than normal-weight people. Obese women in Maxfield and Konishi's (1966) study were as active as normal-weight women when subjects wore pedometers for 48 hours. When Williams and colleagues (1989) observed subjects on an activity field for one hour, they found no differences in activity level between normal-weight and overweight individuals. According to information obtained from questionnaires, Baecke et al. (1983) noted no difference in activity levels of normal-weight and overweight men and women.

In two of these studies, it might be possible to conclude that measurement time was either too brief, or there was opportunity for distortion. However, in Tryon's (1987) study, overweight and underweight subjects wore Timex motion recorders for two weeks, and readouts indicated that overweight men and women, and underweight men were about equally as active. Although the average overweight subject was only 18-20 percent heavier than normal, Tryon concludes that activity level cannot entirely account for differences in weight. These subjects were college students who were only a few years older than Waxman and Stunkard's (1980) obese boys, and results of these two studies suggest that when some obese people are quite young, inactivity may not be a factor contributing to their condition.

It also may be that obesity needs to reach a certain level before it restricts activity. This effect could occur suddenly, as suggested by catastrophe theory (see Stewart, 1983), or it could be a gradual slowdown that is linear with increasing weight gain. For example, in one study, men who were moderately obese walked an average of 4.3 miles more per day than severely obese men; and normal-weight men walked an equivalent of 2-8 miles per day farther than moderately obese men (Sopko et al., 1984). Obese men and women spent more time in bed and considerably more time sitting than normal-weight individuals (Bloom & Eidex, 1967); and obese women walked an average of

2.0 miles per day compared to 4.9 miles per day for normal-weight women in Chirico and Stunkard's (1960) study in which subjects wore pedometers for one week. Lewis et al. (1976) has found that middle-aged women are typically sedentary, and this is evidenced in Curtis and Bradfield's (1971) study during which six obese women did very little standing or walking.

Obese men in Chirico and Stunkard's (1960) study walked, on average, much less than normal-weight men, but there were several obese men who were more active over a two-week period than most of the normal-weight men. It seems likely, based on research reviewed in the present study, that there are obese males who are as active as nonobese males. On the other hand, there is little evidence that obese females of any age are as active as normal-weight females.

Many women may maintain obesity primarily by inactivity and some men who are active may maintain obesity by excessive intake. If this is true, data should find overweight women, in general, do not overeat, and it should be inconclusive as to whether or not men overeat. Most studies examining intake in humans rely on recall methods, and the veracity of these reports is questionable. Several researchers have reported that obese women eat the same or less than normal-weight women (Baecke et al., 1983; Maxfield & Konishi, 1966; Bennett & Gurin, 1982; Curtis & Bradfield, 1971), while obese women in Beaudoin and Mayer's (1953) study reported a wide range of calories consumed.

Binging

It is possible that many obese men and women consume the same amount or fewer calories than normal-weight people, but a primary difference may be that overweight people occasionally eat excessive amounts of high-calorie food (Woolley & Woolley, 1984; Herman & Polivy, 1984). There is a growing body of evidence supporting this hypothesis. Binge eating is defined by Loro and Orleans (1981) as "consuming large or enormous quantities of food in short periods of time." Loro and Orleans studied overweight subjects at Duke University's Dietary Rehabilitation Clinic, and found more than 20 percent of the men and women binge at least once a week on high-calorie, favorite foods. Marcus, Wing and Lamparski (1985) gave 432 obese women the Binge Eating Scale, a self-report measure which attempts to assess the extent of binge eating in respondents. Almost one-half (46 percent) the subjects reported serious problems with binge eating.

People who binge can be normal-weight or overweight, but they are defined as dieters who, by definition, are restrained eaters (Polivy, 1976). To be on a diet means that one cannot eat with abandon, but must follow one or more rules. Even if a person is on an ice cream diet, eating ice cream becomes a rule, not necessarily a choice. Many overweight individuals are continuously attempting to restrain their eating in a manner that will effect weight loss, and it is likely that many of these people are, overall, exerting more self control than the typical normal-weight person. To say that overweight people have no self control, while thin people have a great deal of self control may be untrue.

When self-control is seen as a temporal issue (Ainslie, 1974; Rachlin, 1974), the overweight binger can be defined as a person who is constantly trying to defer the small, immediate reinforcer of good-tasting food in favor of the large, delayed reinforcer of a thinner body; this person is usually but, unfortunately, not always successful. If an overweight individual eats an excess of 3600 kcal a week, the equivalent of three pints of gourmet ice cream, she will maintain her extra weight even though she eats normal amounts of food the remainder of the week.

Dietary Fat

It is also possible that some overweight people are not bingers, but consume a wide range of calories over an extended time. The Lissner et al. study (1987), in which 24 female employees at Cornell University ate meals over a six-week period that varied only in fat content, showed that there was more variation in intake as fat content changed for obese subjects than in leaner subjects. Unfortunately, this variation was a result of *excess* energy consumption on the high-fat diet. The Lissner et al. study indicates that a diet high in fat can lead to overconsumption in overweight individuals. Rats overconsume calories on high-fat diets (Blundell, 1984; Blundell, 1987; Rolls et al., 1980), and so do humans (Sims, 1989; Dodd, Birky & Stalling, 1976; Van Itallie, 1979).

The image of the fat person eating inordinate amounts of sugar is apparently unsubstantiated, because sugar consumption is lower in overweight people than in normal-weight people (Bierman, 1979). One gram of sugar has only 4 kcal, whereas the same amount of fat contains 9 kcal, more than twice the number of calories contained in sugar. Unfortunately, much confectionary and other sweet food also contain large amounts of fat, and it is the fat that leads to obesity.

There is little obesity in populations that consume high-fiber diets that are low in fat (Van Itallie, 1980). Carbohydrates are not metabolized as efficiently as fat because excess carbohydrates are not deposited directly as fat (Sims, 1989), which is stored almost immediately. When Sims overfed volunteers an excess of about 860 kcal of fat per day for 83 days, weight gain was considerable. When other volunteers were overfed the same number of calories over the same period, but the excess calories were a combination of fat and carbohydrates, there was proportionally less weight gain.

Sims (1989) uses the Chinese diet as a model low-fat diet, containing about 15 percent fat, although the typical Chinese consumes 20 percent more calories per body weight than Americans. At present, there is little obesity in China, although Sims predicts this will change with the invasion of high-fat fast food. Fat intake in the typical American diet may be as high as 44 percent (Sims, 1989), up from 27 percent in 1910, while Block, Rosenberger and Patterson (1988) estimate that adults, on average, obtain about 36 percent of their calories from fat. This excessive amount of dietary fat has paralleled increasing obesity in Americans, while at the same time, calorie consumption has declined ten percent over the past century (Brownell & Stunkard, 1980).

The Obese and Good-Tasting Food

The above studies indicate that many people are attracted to the abundance and variety of easily obtainable high-calorie foods that are plentiful in developed countries (Booth, 1980). The obese may not be driven by excessive hunger, but by the enjoyment of eating. In the common vernacular, these people may "live to eat," although evidently not just anything in sight. Like the VMH-lesioned rat, the overweight person seems to be finicky.

Van Itallie (1984) supplied obese and nonobese people living on a metabolic ward a nutritionally complete, bland liquid diet that was provided on demand by an automatic dispensing device. The normal-weight subjects took enough of the liquid to maintain their weight; in contrast, most of the obese subjects rarely consumed more than 25 percent of the calories required to maintain their weight, and they rapidly lost weight. In a similar study, Hashim and Van Itallie (1965) noted that two normal-weight subjects drank 3000 or 4400 kcal a day from a similar dispenser, while a 400-lb man consumed only 275 kcal daily.

The Obese and Distribution of Intake

A second finding in these studies is the difference in the feeding patterns between the obese and normal-weight subjects. Although the liquid was freely available, the nonobese subjects in the aforementioned studies took their meals three times a day in calorically equivalent units that coincided with typical meal-times; on the other hand, the obese subjects took varying amounts of liquid at unequally spaced intervals throughout the day.

Distribution of intake, including meal size, number of daily meals eaten, and time of meals, plays an important role in determining obesity in both humans and rats. Laboratory rats are nibblers; they eat very small amounts of food almost continuously. When they are forced to consume their ad lib amount in one or two meals a day, body fat increases; the gastrointestinal tract enlarges, especially the stomach; and the animals seem to become more sedentary (Fábry & Tepperman, 1970). Blundell (1987) grouped rats according to the amounts of food they customarily ate during a single eating bout. Both groups were then given a high-calorie drink ad lib in addition to chow. The group called "gorgers" gained weight more rapidly than the "nibblers." There was a positive correlation (.54) between meal size and fat cell number, which demonstrates the tendency of increased efficiency of fat storage when food is eaten in large meals (Sims, 1989).

It is difficult to observe meal size in humans; however, Fabry and Tepperman (1970) noted that boarding school students who ate three daily meals weighed more, on average, than students in schools that served five or seven meals a day. Size of meal is related to number of meals eaten and, in the above studies, organisms weighed less when they ate several small meals as opposed to the same amount of food concentrated in fewer and larger meals.

But even when more meals are consumed resulting in a higher-than-normal calorie content, weight gain seems to be prevented. Fabry and Tepperman (1970) fed normal-weight men and women an extra 1400 kcal spread throughout the day, and they did not gain weight. But when normal-weight subjects were given the extra calories as part of a two-meal-per-day regimen, they gained weight in proportion to the caloric excess. Similarly, Japanese sumo wrestlers, who are very obese, eat about 5000 kcal a day (Nishizawa, Akaoka, Nishida, Kawaguchi, Hayashi & Yoshimura, 1976), but they consume all their food in two daily meals.

The American lifestyle encourages small meals during the day and a large evening meal before bedtime, a pattern which is seen especially in overweight persons who eat little or no breakfast and ingest a large number of calories in the evening. This kind of eating pattern promotes fat storage (Sims, 1989), and because infrequent meals are associated with obesity (Fabry & Tepperman, 1970), it is important for people to spread food intake throughout the day if they want to prevent weight gain (Sims, 1989).

Other Environmental Differences Between the Obese and Nonobese

It appears that there are lifestyle differences between obese and nonobese people, and they can be seen in food choices, especially the amount of fat in the diet; meal number and size; and amount of activity expended. Biological factors cannot be discounted in the development and maintenance of obesity, but it is apparent that environment plays an important role, with evidence supporting the hypothesis that there exists an obese lifestyle. Spouse pairs are often the same fatness, and people who are overweight have obese pets (Dietz, 1987). There is evidence, however, that spouse-pair correlations are due in part to assortative mating (Price, 1987), but research is not conclusive as to whether or not pet ownership is assortative. Obesity is directly related to socio-economic status; for example, in a survey of 110,000 Manhattan women, 30 percent of respondents in low socio-economic status (SES) were obese and only 5 percent of those in the upper SES group were obese (Stunkard, 1986). Particularly in western societies, as SES rises, the prevalence of obesity in women diminishes.

Obesity is virtually guaranteed in individuals who are sedentary, eat a high-fat diet, and consume large meals. Further, if one's cohorts are obese, one is more likely to have a lifestyle in which obesity is acceptable. Factors that are endemic to the American way of life contribute to this profile. Television, high-fat fast food, and automobiles ensure a growing population of overweight people.

Behavior Modification

There has been an abundance of research into the modification of feeding in overweight people who desire to lose weight. Behavioral treatment for obesity is fundamentally different from alternative forms of treatment, such as special diets, drugs, or surgery, in that the goal is to alter the obese person's eating style and lifestyle (Wilson & Brownell, 1980). The underlying logic is that when behavior is changed in a manner that results in reduced caloric consumption and increased energy expenditure, the person is in a negative energy balance and will therefore lose weight.

Components of Behavior Modification

Analyzing antecedents and consequences of behavior has traditionally been the cornerstone of behavior change, and obesity research is no exception. Albert Stunkard, professor of psychiatry at the University of Pennsylvania, has studied eating disorders for 30 years. Stunkard (1984) has listed five primary elements in behavioral treatment for obesity that are necessary, if not sufficient, to effect weight loss. These elements are (1) stimulus control, (2) eating management, (3) rewarding consequences, (4) exercise, and (5) cognitive restructuring.

Self-Monitoring

A further important element in obesity treatment is self-monitoring of behavior (Foreyt & Gotto, 1979), which will be discussed separately because it plays an important role throughout the entire process of behavior change. Self-monitoring is used in essentially all behavioral programs, because feedback has always been considered an important component for lasting behavioral change (Brownell & Foreyt, 1985). Clients are given diaries in which to write down everything they eat and drink, as well as the time, place, number of people present, and perhaps mood at the time of eating. The diaries are brought to meetings, and progress, problems and goals are discussed with the therapist. There are several positive factors obtained from self monitoring: The person becomes aware of his or her behavior, proper maintenance of the diary is an indication of the person's motivation to make necessary behavioral change, and the therapist can easily note problem areas that require modification (Brownell & Kramer, 1989). The diary specifies how the changes are occurring and under what circumstances; and because the diary highlights problem areas, the client may be rewarded by noting progress in dealing with them. Self-monitoring is useful not only for eating management, but for recording exercise, nutrition, and relevant social factors.

Stimulus Control

Stimulus control consists of modifying cues that precede eating (Foreyt & Gotto, 1979). There are numerous examples of stimulus control strategies, including:

1. Limit at-home eating to one place in the house, preferably the kitchen/dining table. Never eat anywhere else at home.

2. Eat at the same time every day. No between-meal snacking.

3. Eliminate all distractors, such as reading or watching television, that may be powerful reinforcers when paired with eating.

4. Never shop when hungry; shop with a list, pay with cash, and take a limited amount of money.

5. Food preparation may require techniques to prevent sampling, such as wearing a surgical mask or rubber gloves. One should never prepare more than will be eaten at one meal, and any leftovers should be discarded.

6. Low-calorie foods should be easily accessible; fattening foods should either be banned from the house or, at least, kept out of sight.

These methods were predicated on the assumption that obese persons are particularly responsive to external cues and exposure to cues leading to eating causes them to eat regardless of their level of hunger (Schachter & Rodin, 1974). Although later research indicated that externality is not indigenous to obese persons (Brownell & Kramer, 1989; Rodin, 1989), behavior therapists continue to make stimulus control a fundamental part of treatment because controlling antecedents to a problem behavior is a necessary component of behavior change.

Eating Management

There is some indication of an obese eating style and, for this reason, learning to eat like a nonobese person has become a part of behavioral treatment for obesity (Dodd et al., 1976; Gray, 1989). If, for example, the obese are fast eaters and overeat before they feel the physiological effects of fullness, teaching them to slow down when eating may allow satiety mechanisms to take over before overeating occurs (Foreyt & Gotto, 1979). Clients are therefore taught to eat more slowly, to return utensils to the plate between bites, to drink water between bites, or to take breaks between courses. Meal length is increased as time between bites is increased. Many researchers are no longer convinced of the existence of an obese eating style (Mahoney, 1975; Striegel-Moore & Rodin, 1986) because some data show no difference between obese and nonobese eaters. Nevertheless, eating management is an important component in a behavioral package.

Rewarding Consequences

Rewarding consequences may be one of the weakest components of behavioral treatment for obesity; there has not been a great deal of innovation in this area, and researchers often seem to consider pounds lost as sufficient reward. Programs are sometimes designed to use money as a reward for attendance, weight loss or behavior change, by requiring a large deposit at the inception of the program which is returned later for complying with the contract. This contingency may discourage unmotivated people from joining the treatment and it may encourage people to remain in the program (Brownell & Foreyt, 1985). Jeffery, Thompson and Wing (1978) required a $200 deposit from 31 severely obese adults in a behavioral weight loss program, with a portion of the deposit refunded each week for either attendance, calorie restriction, or weight loss. Contract groups lost an average of 20 lb in the ten-week program, a higher-than-usual amount for behavior modification programs, and participation remained high; in a no-contract control group, attrition was greater than 50 percent. Wysocki, Hall, Iwata and Riorden (1979) required overweight subjects to deposit valued personal items which were returned each week for fulfilling an agreed-upon number of aerobic points for that week. At the one-year follow-up, six of the original eight subjects were maintaining or exceeding exercise levels contracted for in the study.

Exercise

The Wysocki et al. study (1979) is an example of the way exercise has become a vital component to behavior modification (Foreyt, 1987). It has been found that clients often abandon behavioral techniques once treatment has ended; however, groups that incorporated exercise in their regimen have been more successful at maintaining weight loss (Martin, Dubbert, Kattel, Thompson, Raczynski, Lake, Smith, Webster, Kora & Cohen, 1984). Dahlkoetter, Callahan and Linton (1979) placed 44 moderately obese women in either a behavior-modification-only, exercise-only, or combination group. The combination group lost 13.3 lb (about one-third the average amount overweight) which was twice as great a loss as either the behavior-modification- or exercise-alone group. At the six-month follow-up, the combination group was continuing to lose weight, while the other two groups were either maintaining their losses or regaining. Although people occasionally lose large amounts of weight from engaging in exercise (for example, see Keefe & Blumenthal, 1980), most people are not sufficiently committed to an exercise regimen to dedicate the necessary amount of time and effort that would provide impressive results.

Cognitive Restructuring

The final element on Stunkard's (1984) list of behavior modification elements in weight loss is cognitive restructuring, a technique that attempts to change private, verbal behavior relating to one's body image. The assumption is that a woman who sees herself as a fat slob is going to have a very difficult time losing weight. Cognitive restructuring is an idea that seems appropriate and is intuitively appealing, but there is "only preliminary evidence" that including cognitive techniques enhances weight loss and maintenance (Brownell & Wadden, 1986).

Effectiveness of Behavior Modification

Foreyt, Goodrick and Gotto (1981) have found that people who are able to lose weight without professional support usually do so without using behavioral techniques, and people who have been trained to use behavioral techniques often report that they stop using them following treatment termination. Only 3 of 44 original subjects in Katahn et al.'s (1982) study were still using behavioral eating strategies posttreatment; and Jeffery, Vender and Wing (1978) reported clients used an average of 9.4 of 21 techniques immediately after treatment termination, but only 6.6 by the time of follow-up. If this is so, of what value are behavioral techniques? If a client wears a surgical mask while preparing dinner because she trusts the therapist's good judgment, but the behavior is so unappealing she cannot incorporate it into her life, and if weight loss for her trouble is extremely modest, why should she continue the behavior? In fact, the client usually returns to her old eating patterns soon after treatment termination (Foreyt et al.,1981).

Conclusions regarding the efficacy of behavior modification for weight loss are no longer enthusiastic. Weight losses have averaged about 1.2 lb per week in behavioral treatment programs (Foreyt, 1987), which means that if a woman entered treatment weighing 200 lb and was in treatment for ten weeks she would, on average, end treatment weighing 188 lb, still considerably overweight. Bennett (1986) analyzed 105 studies using behavioral treatments for obesity published before 1985 and found a mean weight loss in 6121 clients to be 12.4 lb.

Because of these modest weight losses, behavior therapy changed in the 1980s. Brownell and Kramer (1989) note that early programs were quite narrow in scope and focused primarily on eating. Contemporary programs are more comprehensive and include more nutritional education, social support and, as noted above, exercise and private behavior. Rather than recycling marginally effective treatments, novel techniques are being tried. For example, researchers at Eastern General Hospital in Edinburgh have developed a nylon cord that fits snugly about the waist and remains throughout treatment and follow-up. As weight is lost, the cord is tightened so that it is comfortable at the client's current weight, but becomes tight due to stomach distension or weight gain. Of an original 40 subjects, 14 continued wearing the waist cord at a one-year follow-up, and they had lost an additional 10.6 lb, on average, posttreatment (Simpson, Farquhar, Carr, Galloway, Stewart, Donald, Steven & Munro, 1986). In no other known study, has a substantial number of subjects continued to lose weight after treatment termination. The authors say that the cord is an "effective biofeedback mechanism," in that clients have a method for continuously monitoring consequences of their eating.

Because of occasional outcomes such as found in the Simpson et al. (1986) study, Brownell and Jeffery (1987) contend that treatment has improved. In most cases, programs are longer and subjects are heavier than in the previous decade, which makes a loss of several pounds easier. There is also the possibility of publication bias, in that studies using innovative treatments may not be published if results are not impressive. Foreyt (1987) agrees that behavioral treatment has changed since the 1970s, and this has been reflected in an increased average weight loss; however, this is due to increased treatment length, because clients continue to lose 1.2 lb per week.

Although average weight losses have increased somewhat, with 20-30 lb losses not uncommon (Brownell & Kramer, 1989), there is great variation in pounds lost among participants. Some clients lose much more weight than others, who may lose very little or none; for example, Katahn et al., (1982) obtained treatment effects that ranged from 0.5 to 40 lb.

Wilson and Brownell (1980) caution that such variability is not a good sign of treatment efficacy and that the critical variables governing weight loss have not yet been identified. It is possible that the current behavioral methods are appropriate only for a selected number of individuals having particular eating disorders. Wilson and Brownell also say that attempts to identify accurate variables that are predictive of treatment outcome have been unsuccessful, and this may be the "Achilles Heel" of behavioral weight-reduction research (Johnson, Wildman & O'Brien, 1980). It is therefore difficult to draw conclusions regarding effective treatment components. Very few researchers collect adherence data; of those who do, many fail to report them.

Maintenance

In recent years, behavior therapy has emphasized maintenance of weight loss, "which implies something worth maintaining" (Brownell & Jeffery, 1987). Assuming there is, how well has weight loss been maintained? The results are equivocal, with Stunkard (1984) calling maintenance a "great strength of behavior modification"; while Perri, Shapiro, Ludwig and McAdoo (1984) contend that the effects of behavior therapy for obesity generally "evaporate over time," and Wilson and Brownell (1980) say that behavior treatment is no exception to the trend for high relapse in obesity programs. Typical follow-up data show impressive maintenance in some clients, while many others either regain weight lost in treatment or weigh more than they did pretreatment (Martin et al., 1984). In many cases, because subjects enter treatment at such a high weight, they continue to be very obese at follow-up (Katahn et al., 1982).

Because weight loss cannot be maintained without continuing behavioral change, relapse prevention training is now built into most treatments (Brownell & Wadden, 1986). This is essentially a cognitive treatment in which clients are taught to identify and deal with high-risk situations and to avoid the guilt and loss of control that follows small transgressions.

Results of relapse-prevention training are mixed; they only seem to be effective when combined with other treatment techniques. For this reason, researchers usually rely on a multimodal package, the logic being that something is more likely to be found that works if many techniques are tried. Marlatt and Gordon (1980) call this the "shotgun" approach, and it has strengthened treatment effects, but not maintenance.

Brownell and Kramer (1989) mention several problems with follow-up data: (1) It is difficult to determine if continued weight loss is due to treatment that occurred months or years ago, or to intervening factors that may not be apparent in a follow-up interview. (2) If two people show a net gain over the course of a year, it is possible that one person gained the weight slowly over time, while the other regained and lost weight several times. As the interval between assessments increases, errors interpreting intervening events become larger. (3) How does one assess treatment effects if the person went on to join another treatment group after termination of the treatment in question?

In conclusion, weight losses due to behavior modification treatment are usually modest and the few pounds lost may not be regained. Behavior therapy for obesity has been able to help only those with a few pounds to lose (Foreyt, 1987; Wilson & Brownell, 1980), because they will likely reach goal weight at treatment termination and maintain the loss. The ideal candidate for behavior therapy should probably not be more than 10 to 20 lb overweight, with more drastic approaches necessary for more overweight clients. For the "vast majority of chronically obese patients in our society" behavior modification may be ineffective (Foreyt & Gotto, 1979).

Weight-Loss Diets

The person who wants to lose weight must either decrease intake, increase output, or do both at the same time so that her body will be in negative energy balance (Booth, 1980; Chlouverakis, 1975). The dieter's goal must be to maintain a long-term state of negative energy balance -- there is no other way to lose weight. She can, of course, learn to accept and live with her overweight condition (Hernandez & Hoebel, 1980); in fact, Woolley and Woolley (1984) believe that there is little evidence favoring treatment for any but massive, life-endangering obesity. Nevertheless, most overweight people continually foster the hope that they will somehow lose their excess weight, and they grapple with the problem by embarking on an endless cycle of dieting. Results from a 1985 Gallup poll indicated that 31 percent of all American women between the ages of 19 and 39 diet at least *once a month* , and one out of every six women considers herself a perpetual dieter (Brownell, Greenwood, Stellar & Shrager, 1986).

Low-Calorie Diets

Traditionally, the dieter attempted to follow an eating regimen that was sufficiently low in calories to facilitate weight loss. If a woman consumes about 3000 kcal/day, it would seem to be fairly simple to cut a few calories here and there, enabling her to lose weight. A reduced-calorie diet may be the "most direct approach" to weight reduction (Van Itallie, 1980), although cutting calories or reducing intake, in any way at all, means the dieter must eat less than she wants or likes, and she must do this over prolonged periods of time.

Diets are appealing because, in many ways, they seem so simple and effortless (Bennett & Gurin, 1982); one counts calories as they are consumed, and stops eating each day when the prescribed limit has been reached. Alternatively, the dieter can use a menu that allows so many calories at each meal and she merely has to measure quantities allowed. Counting calories is "simple" once the technique has been mastered (Chlouverakis, 1975), and it was once believed that the only difference between normal-weight and overweight people was that overweight people didn't know how to count calories (Van Itallie, 1980).

There is little question that a person who carefully counts calories and reduces intake below output will eventually lose weight, and if the dieter has elementary knowledge of nutrition, she can create her own low-calorie diet. The easiest and most common method is to eat normally, but cut down on portions (Atkinson, 1989), or the dieter can pick up almost any magazine or select a book from the array of self-help and diet books and create her own diet. There is a myriad of available resources from which to obtain a low-calorie diet (Brownell,1986), including pamphlets from government agencies, private groups such as the American Heart Association, insurance companies, and even food companies. Television and radio stations have aired diet specials in which a celebrity embarks upon his or her own diet with the help of guest experts, and the weight change is publicly monitored. Viewers are encouraged to follow through with the same plan on their own. The quality of such advice ranges from scientifically validated to dangerous (Brownell, 1986.) and the public health impact is not known.

Reduced-calorie diets usually specify a particular number of calories that should be consumed each day; Brownell and Kramer (1989) say that most behavior modification programs suggest about 1200 kcal/day for women. Another strategy is to restrict calories according to the dieter's current weight; Wing, Epstein and Shapira (1982) suggest 13 kcal per pound minus 1000 kcal. Other researchers merely say the dieter should "eat less of everything" (Van Itallie, 1980).

If a person maintains a 500 kcal/day negative energy balance, she will lose one lb/week (Garrow, 1978), and it will take six months to lose 25 lb. Many dieters are too impatient to change their eating habits for a mere one-lb-per-week weight loss, and furthermore, when people reduce intake even a little, they can suffer from hunger and discomfort. When calories are reduced substantially, dieters are often left with feelings of hunger that are associated with semistarvation (Mickelsen, Makdani, Cotton, Titcomb, Colmey & Gatty, 1979). Nisbett (1972) says that if obesity is the normal state for an individual, a weight-reduction regimen will put the person in a state of constant starvation. Low-calorie diets may be even more stressful than total fasting (Stunkard & Rush, 1974), and added to the stress of hunger is evidence that food tastes better when one is hungry (Nisbett, 1972), which will make it more difficult for the dieter to stay within imposed dietary bounds.

Breaking the Diet

The issue of dietary bounds has been discussed at length by Herman and Polivy (1984) who contend that dieting is primarily a cognitive event because, at all costs, the dieter must remain within some caloric boundary in order to be dieting. Once this boundary is transcended, the dieter is at risk for uncontrolled eating, an event Herman and Polivy call the "what-the-hell" effect. Dieters often renounce adherence to the diet after they have transgressed only slightly, often after they have taken only a bite or two of a forbidden food. This seems to trigger an eating binge which is followed by termination of the diet.

Contrary to Herman and Polivy's (1984) interpretation, the diet boundary may be self imposed because of the information the dieter is given that instructs her to "Eat less than you expend," "Maintain a 500-Calorie-per-day negative energy balance," "Eat only 1200 calories or you won't lose weight," and so forth. The reason these instructions may be so difficult to follow, and thereby cause excessive rigidity in diet planning, is that the dieter does not know her true caloric boundary. If she does not know what her expenditure is, she can only estimate the number of calories she can eat and still lose weight. Because she wants to succeed on her diet, she may insist on following a regimen that will ensure weight loss, one that is very low in calories, one that puts her in a constant state of starvation.

The "Yo-Yo" Syndrome

In the Keys et al. study (1950) 32 conscientious objectors consumed about 1570 kcal/day for six months. Each day they received 50g protein, 30g fat and the remainder in carbohydrates. The diet primarily consisted of whole-wheat bread, potatoes, cereal, turnips, cabbage and a little fruit; subjects ate very little meat and dairy. Weight loss averaged 24 percent and was lost quickly and easily. It is likely that most of these men had never dieted before and they did not suffer from what Brownell et al. (1986) call the "yo-yo" syndrome. Most obese persons lose and regain weight over and over during their lifetimes (Brownell, 1984); and these weight fluctuations make weight loss more difficult following each weight gain.

The yo-yo syndrome also occurs with laboratory rats that repeatedly gain and lose weight. Brownell et al. (1986) gave rats high-fat diets for 46 days, and they became as obese as overweight controls. The rats were then placed on standard laboratory chow and they returned to normal weight in 21 days. A second cycle of overfeeding was implemented and the rats reached the weights of overweight controls in only 14 days, but it took 46 days to lose the excess weight. Similar to Brownell et al's. rats, humans who lose and gain weight many times seem to regain lost weight more and more easily, and they lose the same weight with greater difficulty each time they diet. Because many obese people defend their higher weight as vigorously as normal-weight individuals defend lower weights, they usually regain their lost weight. Similarly, subjects in the Keys' et al. (1950) study hardly stopped eating until they had regained all the weight they lost during the semistarvation period. Keys' subjects often said they were still hungry even as they were finishing very large meals; they said they were hungry when they physically could not ingest any more food. Many subjects were eating over 5000 kcal/day, and a daily intake of 11,000 kcal/day was not unusual.

Weight that is lost solely through caloric restriction will include a large loss of lean tissue; it is an estimated 35-45 percent of total weight lost on most diets (Wilmore, 1983), so every time the person loses weight, more and more lean tissue is lost. Because the metabolism is primarily determined by amount of lean tissue, if there is less to metabolize, expenditure will be lower with decreasing weight. A low metabolism coupled with a state of semistarvation places the dieter in an almost hopeless position, where the smallest temptation can tip the balance against continuing the diet. Subsequently, more weight is gained and it will likely be higher than it was before beginning the last diet (Sjöström, 1980).

Poor Prognosis for Low-Calorie Diets

An important result from the Keys' et al. study (1950) is the effect of the calorie restriction on the subjects. Diets consisting of 1500 kcal/day for men are typical, but if men could become emaciated on a diet of 1570 kcal/day, it follows that a reduced-calorie regimen places dieters in a state of starvation, even if they do not yet look emaciated. McArdle et al. (1981) say that the results of this study "lead us to question seriously the chances the 'average' person has for success with such long-term calorie deprivation, independent of their body fat content."

Results of the Keys' et al. study (1950) also support the suspicion that people do not accurately record intake when they are not dieting and, of course, recording of intake during the diet may be erratic. Many obese individuals have poorly structured eating patterns, so it is especially difficult for them to count calories (Van Itallie, 1980). Poor calorie counting coupled with constant hunger make low-calorie diets difficult to maintain, and because calorie counting has been an ineffective method for weight control, alternative dietary regimens have been devised.

Fasting

There is some evidence that weight loss is more reliable when a person eliminates all food and goes on a complete fast. Short-term fasting with a duration of 10 to 14 days is relatively safe for many individuals who are under close medical supervision (Stunkard and Rush, 1974). McCuish, Munro and

Duncan (1968) supervised 25 obese individuals (>40 percent overweight) on a fast of water and other noncaloric drinks for 12-40 days. They lost from 9-58 lb, with an average loss of 26.7 lb. Besides the fact that prolonged fasting is potentially dangerous, this study amply demonstrates the other major problem with fasting, which is poor maintenance of lost weight (Wadden, 1983). McCuish et al. said that all but one of their subjects regained weight (from 4 to 101 lb), and the one "winner" kept the fasted weight off "at the expense of his mind and job."

Very-Low-Calorie (VLC) Diets

A recent development in the medical treatment of obesity is the use of very low calorie (VLC) diets. A VLC diet is defined as a daily intake less than 500 kcal/day (Atkinson, 1989) or less than 600 kcal/day (Wadden & Stunkard, 1986). These diets are nutritionally adequate for long periods of time and appear to be safe as long as the patient is supervised by a physician (Wadden et al., 1983). Treatment is usually conducted by hospitals on an outpatient basis, is very expensive, and thus is limited to persons who are either very motivated or have sufficient means to pay for it. The client receives 70 to 100g/day of high-quality dietary protein which preserves lean mass while promoting fat loss (Wadden & Stunkard, 1986). The VLC diet is especially good for people suffering from moderate to severe obesity, or patients who are at least 40 lb overweight. Weight is lost rapidly; in 2 or 3 months, people can lose 40-50 lb (Brownell & Foreyt, 1985). Because people seeking VLC dietary treatment come from an upper-class population, treatment outcome is likely positively influenced.

The most commonly used VLC diet is Optifast 70®, manufactured by Sandoz Nutrition, Minneapolis, Minnesota (Kirschner, Schneider, Ertel & Gorman, 1988). One day's supply of Optifast contains 70g protein from pasturized egg whites, calcium caseinate and nonfat dry milk; 30g of carbohydrate, 2g fat, and vitamins and minerals. When taken five times/day, the person consumes about 450 kcal/day.

One very large study placed over 4000 clients on Optifast 70® (Kirschner et al., 1988); about 25 percent quit the program during the first three weeks, and approximately 25 percent approached or attained ideal weight. Of these successful clients, females lost an average of 66 lb. At 18 months, 35 percent of the successful females maintained the loss to within 10 lb, while most of the other subjects who never approached goal weight regained much or all of their lost weight. Results from this study suggest that successful maintenance of weight loss on a VLC liquid diet depends on how close subjects come to their goal weight, although the few follow-up studies of VLC diets indicate that weight loss is poorly maintained (Brownell & Foreyt, 1985).

Because weight loss in behavioral treatments is usually more lasting than that in most other diets, combining a VLC diet with behavior modification utilizes the most successful weight-loss treatment and the most successful maintenance treatment in one package. Wadden, Stunkard, Brownell and Day (1984) conducted an intensive 6-month program for very obese subjects which combined a VLC diet with behavior modification. Weight loss averaged 45 lb and subjects lost 36 percent of their excess weight which was maintained at one-year follow-up; subjects had regained only an average of 4.6 lb. When treatment effects were compared between VLC diet alone, behavior modification alone and a combination of the two, at posttreatment follow-up, the VLC diet-alone group showed by far the most posttreatment regain (Wadden & Stunkard, 1986). Because the addition of a VLC diet to a behavior modification regimen may increase and maintain weight loss, the combination of the two therapies has resulted in the most consistently successful weight-loss technique devised so far.

Other Kinds of Diets

With VLC diets beyond the financial means of most dieters, other methods must be found for losing weight. Many diets make the job of controlling energy intake easier than counting calories by simply prohibiting certain dietary items or classes of foods. For example, many persons obtain up to 25 percent of their daily caloric needs from alcohol, and abstaining from alcoholic drinks can result in substantial weight loss (Eco, 1986; Van Itallie, 1980).

Besides low-calorie diets, there are low-carbohydrate diets which have met with some success by many dieters (Van Itallie, 1980). Another alternative is to restrict fat from the diet, which makes calorie counting unnecessary because people who stringently restrict fat from the diet have difficulty consuming sufficient calories to compensate for the reduced foodstuff.

Among the more unusual dietary variations are one-food diets that are based on monotony and simplicity (Atkinson, 1989), or which may consist of one food on Monday, another food on Tuesday, and so on. These diets are boring, and aversion is likely to develop, resulting in reduced calorie intake. Their appeal lies in the fact that one can eat large amounts of favorite foods, such as ice cream or milk and bananas which, when eaten day after day, no longer arouse the appetite (Van Itallie, 1980). Needless to say, these diets are unbalanced and deficient in nutrients. Other diets may utilize one item that takes the edge off appetite enough so the dieter doesn't deviate from the regimen. Foreyt , Reeves, Darnell, Wohlleb and Gotto (1986) prescribed 2-3 cups of soup each day to help dieters slow their eating rate or reduce the appetite by filling the stomach. Booth (1980) suggests that dieters who crave sugar indulge a little because of the "well-known appetite-suppressant effect of some confectionary."

Vegetarian and high-fiber diets (Atkinson, 1989) may reduce caloric density, increase eating time and displace other high-calorie foods. Mickelsen et al. (1979) achieved a 19 lb average weight loss in 6 college males who ate 12 slices of reduced-calorie bread/day. At a 9-mo follow-up, those who continued eating large quantities of bread had maintained their weight loss, and those who reduced their bread consumption regained most of their weight. In general, however, diets high in fiber, although popular, have shown poor evidence of success. Many people appear to be unable to make substantial increases in their dietary fiber, and the only diet-related benefit may be that the dieter eats less high-calorie food.

Atkinson (1989) calls some diets "magical," because not only are they novel, they are claimed to have extraordinary power to take off extra pounds quickly and effortlessly. Magical diets may require some rigid compliance schedule and often combine two or three foods in a "recently discovered" way that "melts off fat." These diets have received no scientific validation and many of them are unsound.

Researchers have tried to develop foods or food-like products that are poorly digested (Van Itallie, 1980). Dieters have always hoped to find the perfect diet--one that allows large amounts of high-calorie foods without weight gain, and it is therefore appealing to think of ingesting a highly palatable but little-absorbed ice cream or pastry. Unfortunately, the physiological distress encountered from eating such foods in the form of intestinal and bowel problems may ultimately make these substitutes unsatisfactory.

Medication

If the obese are unable to control intake on their own, there are several possible ways they may obtain help. One method is the use of anorexiant medication. This is usually taken in the form of phenethylamine derivatives (Weintraub & Bray, 1989), usually fenfluramine, which is not related to dextro-amphetamine and methamphetamine, drugs also known as "speed" and that are commonly abused. Safe anorexiants such as fenfluramine, have received negative reviews from both the medical community and the public; Weintraub and Bray say this is partly due to the negative perception society generally has of obesity, although the current political climate that criminalizes many drugs undoubtedly adds to the problem. After medication is stopped, there is usually failure to maintain weight loss, which may be due to clients attributing success to the medication instead of their own efforts (Wilson, 1980). Medication certainly increases the rate of weight loss in persons with or without additional treatment components, but the benefit is outweighed by very poor maintenance of that loss after medication is discontinued (Stunkard, 1984).

Support Groups

Another method for helping the individual lose weight is in the form of support groups, such as Weight Watchers, Overeaters Anonymous, or TOPS (Take Off Pounds Sensibly). These groups are comprised primarily of women (who outnumber men 9 to 1) (Wadden & Stunkard, 1985); they are self-supporting, widely available, and attractive to dieters (Brownell, 1986). Weight Watchers International® was founded in 1963 and presently has about a half-million members throughout the world. A primary attraction of these groups may be the social monitoring, attention and camaraderie found at the group meetings (Stuart & Mitchell, 1980).

There has been little evaluation of organized support groups; usually, available research has examined attrition, a problem that Brownell and Kramer (1989) say complicates interpretation of the reported weight losses. Most reports of treatment success are therefore based on "survivors" of these programs. Brownell and Foreyt (1985) estimate that between 50 and 80 percent of enrollees drop out of self-help groups within six weeks, but many rejoin sometime later. The average person in Weight Watchers has joined three times previous to current enrollment. Another factor that makes evaluation of weight-loss groups difficult is the possibility that people who join a group may be at their peak weights and have recently gained more weight than usual (Brownell & Jeffery, 1987).

Mitchell and Stuart (1984) studied 414 women who joined Weight Watchers in 1982 with an average pretreatment weight of 185 lb. Twenty-five percent (a percentage considerably lower than Brownell and Foreyt's estimate) of these women dropped out after an average of 7.2 weeks. The difference between the dropouts and the stayers was that the dropouts had made significantly more attempts to lose weight in the past few years than the stayers (18.9 vs. 7.0 attempts), and dropouts had consistently less confidence in reaching weight-loss goals as they went through the program. Garrow (1978) queried 600 diet club members in Great Britain and found that of the 341 replies, an average weight loss of 24 lb was achieved after 6 months of membership. At a later follow-up, only 11 percent respondents had maintained their loss, with 7.6 percent weighing even more than they had when they joined the group. It would seem that for a few individuals, self-help groups may be useful; for the majority of overweight people, however, group weight-loss benefits are limited.

Surgery

When all else has failed, and if the individual is severely obese, a last resort is gastric bypass surgery, which may be the treatment of choice when obesity is severe enough to endanger health and other, less dramatic treatments have failed (Brownell & Foreyt, 1985). This kind of surgery may have serious ramifications on the physiology of the person that far outweigh the effects of lost weight (Stunkard, 1986).

A less drastic procedure that can be useful for people with specific cosmetic defects caused by pockets of fat is lipectomy, where fat is suctioned from specific parts of the body. Lipectomy is beneficial for normal-weight women who suffer from bulges in a particular area, such as "saddlebag thighs." Hirsch et al. (1989) recommend that the procedure be used to remove no more than 2 lb of fat.

Failure of Diets to Effect Weight Loss

The above data speak poorly for the ability of almost any treatment to take off weight from an obese person. Drastic treatments, such as surgery and jaw wiring produce dramatic weight losses, but diets that stress a reduction in either all or some food seldom produce weight loss that is sufficient to approach the client's goal weight. Brownell and Jeffery (1987) noted that with the exception of the mildly overweight, even the most successful patients rarely reach their dietary goal. Obesity is usually life long (Weintraub & Bray, 1989), and treatment that lasts for a few weeks or months has little chance for altering a life-long condition.

Successful Diets

Colvin and Olson (1983) studied 41 women who had lost at least 40 lb and had kept the weight off for a minimum of two years. Few of these "winners" had joined a program or support group; most of them lost weight on their own. All subjects knew more about good nutrition than they had known before they lost their weight; they had developed their own dieting strategies and eating patterns that were effective for them and which they now preferred over their old habits. They ate less sugar and fats; they ate more fish, fowl, fruits and green vegetables, and they no longer enjoyed feeling full. Almost all of these women now exercise as a way of controlling their weight. This treatment is neither new nor innovative; it is a common-sense prescription for combining sensible diet with exercise to achieve and maintain weight loss.

In summary, prospects for long-term weight loss from diet alone are slim. The few optimistic threads running through the literature are as follows:

• VLC diets coupled with behavior modification have effectively reduced large amounts of weight and maintained weight loss for a large percentage of patients who have gone on the program. The main drawbacks of this package are the expense, which makes it prohibitive to most dieters, and its poor maintenance record.

• Most successful dieters follow a personalized regimen of healthy eating. This is commonly known as a "sensible" diet and has not been effective for most dieters. Successful weight loss is invariably maintained by continued sensible eating and a program of regular exercise.

• People who drink regularly may lose weight simply by eliminating alcohol from the diet.

• Although high-fiber diets have not been particularly effective, results from Mickelsen et al.'s (1979) study which incorporated large quantities of bread in the diet suggest that a low-calorie diet supplemented with high-fiber, low-calorie bread may effect substantial, long-term weight loss.

SECTION II

Several issues emerge from the preceding review. A primary issue concerns intake, because it is not known if overweight people eat proportionally more calories than their normal-weight counterparts or if their intake is about the same. This question remains unanswered because it is extremely difficult, if not impossible, to know how accurately a person is recording amount and content of consumption; however, there is sufficient evidence that overweight people create inaccurate eating records (Lansky & Brownell, 1982), and this has caused most researchers to abandon them as a means for documenting intake in natural settings.

The instrument that estimates calories in foods prepared for consumption has not been invented. It will have to be small, portable, inexpensive, convenient, safe, and it must not damage or transform the serving into something else. Until such a calorimeter is manufactured, researchers will have to rely on data gathered from eating records, natural observations, or metabolic wards, the latter of which are unnatural, expensive to maintain, and usually attract only the very obese.

Other questions and issues that should be addressed by obesity researchers include the following:

1. It is apparent that a lag exists between intake and output that varies among individuals. For some people, short-term energy regulation is quite good; for others, it occurs only over several days. Little, if any, homeostatic research has tested regulatory differences between normal-weight and overweight people. It is possible that people who are able to match their daily intake

with equivalent expenditure may be less prone to obesity, while those who do not immediately work off temporary overindulgences suffer the long-term consequences of increased weight.

2. There is considerable evidence that hypercellularity is permanent, while hypertrophy can be reduced by weight loss. It is also apparent that people who are moderately overweight are hypertrophic but probably are not hypercellular, because only people who are considerably overweight seem to have an excessive number of fat cells. An argument for most failures to reduce weight is that the hypercellular person will have too much fat even when fat cells are no longer hypertrophic. If this argument were a valid reason for the almost complete failure of overweight people to lose weight, all overweight people would have to be hypercellular. It seems logical that those who possess an overabundance of fat cells should be able to lose weight to the point where the cells attain normal size, yet this does not seem to be the case.

This is not an attempt to undermine the importance of hypercellularity: Sjöström's (1980) examination of overweight children shows the effect of excessive fat cell number in obese children; however, it is possible that weight reduction success is not significantly affected in many people by their number of fat cells.

3. The weight-loss profession continues to offer little that is new or particularly effective, with the exception of VLC diets. Occasionally, however, an innovative study is published that should arouse further interest in researchers. One treatment that achieved a rather large weight loss was that of Mickelsen et al. (1979) who prescribed 12 slices of high-fiber bread daily to overweight young men, who lost an average of 19 lb. Those who continued eating a large quantity of bread maintained their weight loss at the nine-month follow-up. Perhaps

some overweight people would find a diet including a great deal of bread an attractive addition to the popularly portrayed "rabbit food" that seems to be the mainstay of most low-calorie diets.

A second important issue concerns output or energy expenditure. It has not been known if overweight people expend a proportionally smaller amount of energy than normal-weights or if the amount is the same. Fortunately, microcomputer technology has enabled researchers to develop instrumentation that is small, portable, inexpensive, convenient, and safe, and that measures energy expenditure with an acceptable degree of accuracy and reliability. If this equipment is used to measure output in human subjects with varying degrees of fatness, activity level differential, if any, could be found.

The Caltrac estimates RMR by summing energy expenditure based on vertical movement and a preprogrammed formula based on height, weight, age and gender of the wearer (Ballor, Burke, Knudson, Olson & Montoye, 1989). If programmed metabolic data are identical for all subjects, it is possible to note differences in activity between subjects without taking metabolic level into account. In this manner, the Caltrac is similar to a pedometer but, unlike a pedometer, the Caltrac is sensitive to intensity as well as quantity of vertical movement. The Caltrac is small (9.5 cm x 7.0 cm x 1.25 cm) (Washburn & LaPorte, 1988) and lightweight (78g) and can be worn unobtrusively at the waist when clipped to a belt or waistband.

Recent tests of the Caltrac have shown mixed results. Washburn and LaPorte (1988) tested Caltrac devices on 17 subjects who walked over measured distances at normal and fast pace. The device was able to note increased walking speeds in all subjects when worn at the back, and for all but one subject when worn at the hip. Correlations between walking speed and monitor readings were high (hip, $r = .90$; back, $r = 0.81$). Washburn and LaPorte report little influence from body position for the Caltrac, with test-retest reliability of .70 and .87 (hip position) for normal and fast paces; and 0.73 and 0.83 (back position) for normal and fast paces. Overall reliability and validity for the Caltrac were high ($r^2 = 0.79$ and 0.73, respectively).

The Caltrac has been tested on basketball players in a game and the relation between the Caltrac and heart rate estimates of caloric expenditure or video analysis estimates of expenditure were very robust ($r = 0.92$ and 0.95, respectively) (Ballor et al., 1989). Based on this study, the device may be useful for measuring expenditure in free-ranging activities; however, research by Nichols, Patterson and Early (1990) indicates the Caltrac may not be a good measure of individual activity when intensity varies.

Nichols et al. (1990) had young and old adults wear Caltracs while walking on a motorized treadmill at various speeds with oxygen uptake measured by indirect calorimetry. When Caltrac readouts were averaged across workloads, correlations with oxygen uptake were high in the young subjects and much lower in old subjects. When workload influence was removed, correlations were much weaker for young subjects and almost zero for the older subjects.

The study by Williams et al. (1989) brings into question the reliability of the Caltrac when tested in the field. The device was worn one day per week for three consecutive weeks on a large sample and there was poor convergent validity with daily activity logs and the Stanford Physical Activity Recall, which agreed with each other but not with the Caltrac. These results may indicate problems with self-report activity estimates and not with the reliability of the device.

Energy expenditure for some people may vary a great deal from day to day, and this variance could strongly affect correlations between the Caltrac and estimates of expenditure based on recall. It also may be that subjects are tampering with the devices and invalidating data. To preclude this possibility, the sensors should be worn for several consecutive days to eliminate reactivity which might occur during the first few days. The effectiveness of these devices is best measured in a homogeneous group of individuals because if differences can be detected among people with similar lifestyles, the device might be effective at identifying broader differences in more divergent populations (LaPorte, Kuller, Kupper, McPartland, Matthews & Caspersen, 1979).

If individual physical information is not programmed into the Caltrac, the instrument can be used to calculate differences in expenditure across subjects of differing height and weight. If subjects are categorized according to amount of fatness, the Caltrac can determine if there is an expenditure difference among people who are distinguished by amount of body fat. If there is a difference in expenditure between normal-weight and overweight people and, assuming that normal-weight people are more active, the data will indicate that overweight people should increase their activity as part of a weight-loss regimen. Such results would not settle the question as to whether overweight is caused by inactivity or if inactivity is merely a result of overweight, and it is also possible that spending calories similarly to a normal-weight person would not effect much weight loss. Nevertheless, it seems unlikely that an abnormally high set point can be maintained indefinitely if a person eats and moves like a normal-weight person, regardless of whatever genetic propensity for fatness. Unfortunately, there are no mechanisms at this time for accurately and efficiently calculating intake; however, if output is increased to some standard of "normal," perhaps it would be easier to modify intake to a level that simulates feeding in normal-weight people. The first experiment monitored energy expenditure in young, female college students in order to determine if there is a relationship between activity level and amount of body fat.

When the Caltrac was used in conjunction with the Stanford Physical Activity Recall and daily activity logs, there was poor convergent validity between the Caltrac and the two recall measures (Williams et al., 1989). The Caltrac has not been tested for convergent validity with other activity measures, although other portable activity monitors have been tested with the Paffenbarger Survey of activity (Cauley et al., 1984), developed by Paffenbarger et al. (1978), using male Harvard alumni as subjects. A major advantage of the Paffenbarger Survey lies in its brevity; it asks three questions of respondents:

1. How many flights of stairs do you climb each day (ten steps equal one flight);

2. How many city blocks or equivalent do you walk each day (12 blocks are one mile); and

3. What sports are played actively for how many hours a week.

These activities were converted into calories for male respondents as follows: A flight of stairs a day expends 28 kcal a week; a city block a day (1/12 mile) expends 56 kcal a week; and light sports expend 5 kcal a min or 10 kcal a min if the sport is strenuous. Paffenbarger and colleagues found that the least active respondents climbed fewer than 50 stairs and walked less than five blocks per day, and these respondents were at significantly greater risk for CHD.

The Paffenbarger Survey has not been tested on young females and so, for this dissertation, it was necessary to develop calorie expenditure tables for women. If there is a relationship between the Caltrac readouts and caloric expenditure determined by the Survey, the two measures may be useful in a wide range of epidemiological research.

Experiment 1

Method

Subjects

Forty-two female students were recruited from freshman psychology classes at the University of New Hampshire. Respondents who exercised by swimming or engaging in contact sports were not allowed to participate because of potential damage to the Caltrac during activity. Respondents answered a health questionnaire (Appendix A) to detect chronic illness, amenorrhea, or use of prescription medication. Subjects' ages averaged 19.2 yr (range 18-29 yr), with average height at 65 in. (range 60-72 in.) and average weight at 135 lb (range 100-220 lb). All subjects received class credit for participation in the study. Approval for both Experiments 1 and 2 was granted by the university's Institutional Review Board for Human Subjects.

Materials

Equipment. Each subject was given a Caltrac Personal Activity Computer® (Hemokinetics, Inc., Madison, Wisconsin) to wear during her participation. Twenty devices were obtained from the manufacturer and, because of their reputation for breaking or improper functioning, fewer than 20 subjects participated at any one time in order to replace broken devices without losing data.

Testing. Each subject took the Paffenbarger Survey of Activity (Paffenbarger, Wing & Hyde, 1978). Responses from the Survey were transformed into calories expended according to Table 1. Four sources were used to obtain calorie expenditure for various activities in women. Shown are estimates of expenditure, in calories, for walking, stair climbing, and sports in which the subjects said they were active. In order to match the Caltrac program, for the first experiment, all calculations were based on subjects weighing 100 lb.

Table 1
Caloric Expenditure per Minute or Hour for Physical Activities

Activity	Caloric Expenditure
[1]Walking (3 mph)	
kcal per min.	3.1 (for 100 lb)
[1]Weight lifting, floor hockey, ice skating:	5.0 kcal/min @ 110 lb
[2]Stair Climbing	14.5 kcal/min
[2]Bicycling (5.5 mph)	251 kcal/hr
[2]Dancing (moderate)	209 kcal/hr
[2]Running (5.5 mph)	537 kcal/hr
[2]Downhill skiing	483 kcal/hr
[3]Tennis	404 kcal/hr
[3]Volleyball	254 kcal/hr
[3]Swimming	780 kcal/hr
[4]Aerobic dancing	6.3 kcal/min

[1]Durnin and Passmore (1967).
[2]Haycock (1980). It was estimated that one flight (10 stairs) could be climbed comfortably in 7 sec. If a subject climbed 10 flights of stairs/day (70 sec), she would expend 16.92 kcal stair climbing in one day..
[3]Drinkwater (1973).
[4]Nelson, Pels, Geenen & White (1988).

Design and Procedure

Subjects began participation in the experiment based on convenience and availability of Caltracs; this design allowed for Day One to vary across the week between subjects, and any fluctuations in activity that occurred on various days, including weekends, were balanced across subjects. No subject participated immediately before or during the first two days of her menstrual cycle. Research indicates that young women are especially susceptible to dysmenorrhea, or painful menstruation (Gruber & Wildman, 1987), and there is evidence that many women spend extra time in bed and either miss or reduce attendance in activities normally performed at other times.

Subjects met with the experimenter and were given information about the study, but they were not told the hypothesis of the study, which is that there may be a negative correlation between amount of body fat and activity. Each subject signed a consent form indicating her agreement to participate in the study (Appendix B), answered the health questionnaire, and completed the Paffenbarger Activity Survey. Subjects were then given a handout containing detailed instructions for using and caring for the Caltrac (Appendix C1). Before the devices were distributed, identical metabolic data were programmed for each device as follows: Height, 60 in.; weight, 100 lb; age, 20 yr; gender, female. Programming the Caltracs with low resting metabolic rates enabled comparisons of small differences between subjects and allowed results to be generalized to people with low as well as higher metabolisms.

Each subject was then given a Caltrac to wear for six days along with verbal instructions to supplement the written instructions. Subjects were shown how to wear the device on the hip and were asked to wear it for the remainder of the day in order to make certain it worked and to accustom them to wearing it.

Subjects were instructed to reset the Caltrac to zero that night when they went to bed and to put it on as soon as they got out of bed the next morning (Day 1). They were instructed to wear the Caltrac during all waking hours except for bathing or swimming. Subjects recorded in a notebook the times they put on and took off the device in an attempt to account for abnormally high or low readings.

At the end of Day 3, just before going to bed, subjects telephoned the experimenter with the readout on the device and they then reset the counter to zero. They continued to wear the Caltrac for another three days at which time they again telephoned the experimenter with the readout (at bedtime on Day 6). Timesheets and devices were returned to the experimenter soon thereafter. Body measurements (described below) were taken in the Physical Education department approximately one week later.

Body Measurements

Height and Weight. Subjects' height and weight was measured on a Detecto balance-beam scale.

Body Mass Index (BMI). This was calculated from height and weight which were transformed into kilograms and centimeters on the computer by the SPSS^{X} package.

Circumference Measures. A standard tape measure recorded size of waist and hips to determine body fat distribution.

Skinfold Measures. These were taken at the following sites by a trained graduate student in the Physical Education department: Anterior thigh, suprailiac, abdomen, subscapular, and triceps. Lange calipers were used. Body fat percentage was estimated from body density.

Bioelectrical Impedance Analysis. This measurement was performed by the above-mentioned graduate student and data were analyzed using the Lukaski equation, which has a high correlation with underwater weighing (r=.79) and accurately detects small changes in body fat (Ross et al., 1989).

Statistical analysis was performed on the VAX computer system by the $SPSS^x$ program.

Results

Forty-two women participated. Data were not analyzed for three subjects because two of them did not keep appointments for body measurements, and one subject was bulimic with extremely irregular weight and activity fluctuations. Table 2 shows mean, median, standard deviation (S.D.), range, skewness and kurtosis for body and activity measures.

Frequency distributions were computed for all measures. Appendix D shows Pearson product moment correlation coefficients for all variables. Because the primary method of data analysis is correlational and distributions that veer from normal cannot map onto variables with normal distributions, skewness and kurtosis values for each variable were examined. Values exceeding ±1.0 were considered to be sufficiently abnormal to justify recoding that variable into a dichotomy at approximately the 50th percentile or, in the case of net weight change, at zero, with the zero becoming a third variable. The three variables that met the criterion of skewness or kurtosis were Circumference, Total Weight Change and Net Weight Change. The BMI data had skewness of 1.04, but because of high correlations with other body measures, this variable was not dichotomized. Appendix E shows correlations which include the three recoded variables.

Table 2.
Measures of central tendency for estimates of fatness and activity

Variable	*N*	Mean	S.D.	Median	Range	Skew	Kurt.
Age	39	19.2	2.22	18	18-29		
Height (in.)	39	65.1	2.65	64.5	60-72		
Weight (lb)	39	135.0	27.17	133	100-220		
BMI	39	22.4	3.90	21.3	16.9-33.2	1.04	.72
% Body Fat							
Skinfolds	39	23.4	6.18	23.6	13.8-37.4	.43	-.42
BIA	39	28.3	4.88	28.0	20-40	.37	-.24
Circum.	39	.74	0.04	.74	.63-.87	.40	1.52
Paffenbarger (kcal per week)	39	2028	1193.6	2282	168-4746	.37	-.61
Caltrac Total							
Days 1-3	35	5186.5	496.0	5103	4363-6173	.44	-.57
Days 4-6	26	4999.0	353.9	4947	4461-5873	.92	.6
Caltrac/Hour							
Days 1-3	36	26.9	13.07	23.2	5.4-52.4	.51	-.72
Days 4-6	27	19.8	6.55	19.4	7.2-34.9	.49	.44
Change (past yr)	38	14.2	11.9	12.5	0-57	1.44	3.38
Netwt (past yr)	38	.84	8.4	0	-28 to 22	-.41	3.97

Another method used to normalize distributions is to transform data logarithmically. In order to make the distributions as similar as possible, log transformations must be performed on all variables, not only those that appear abnormally distributed. The original frequency distributions were transformed in this manner with log base 10 in an attempt to obtain normalcy. Constants of "1" were added to Circumference and Net Weight Change (hereinafter called "Netwt"), and a constant of "30" was added to Total Weight Change (hereinafter called "Change") in order to obtain minimum values of "one," a requirement for logarithmic transformations. Because 17 of 38 subjects had neither gained nor lost weight, the logarithmic transformations failed to normalize the Netwt distribution:

	Skewness	Kurtosis
Circumference	.28	1.36
Change	-1.05	.4
Netwt	-4.40	23.88

The Paffenbarger Survey data were transformed into a skewed (–1.26) and leptokurtic (1.31) distribution as a result of the logarithmic transformations. Because the transformations normalized only the Change variable to meet the ±1 criterion, correlations based on log transformations were not used.

The following is a breakdown of body and activity measures.

Body Measures

As can be seen from Table 2, average BMI was normal for the age of these subjects, which was primarily 18 or 19 years, according to the chart on page 5 in Section I. Six subjects had a BMI between 25-30, which would classify them as overweight, and three subjects had a BMI above 30, which would classify them as obese (Bray,1987; Gray, 1989; McArdle et al.,1981), while several subjects had fat percentages in the low- to mid-teens. Body fat was frequently greater on the BIA, with some differences as great as 11 percent, and a BIA that was 6 to 8 percent higher than Skinfolds was not uncommon. Low values were considerably higher than low values determined by skinfolds. To test the difference between the means for skinfolds and BIA, a paired *t*-test was performed ($t = -10.08$, $p < .001$), indicating that the differences between means for Skinfolds and BIA were significant.

Correlations for body fat measures that are significant at or beyond the .05 value are listed below. Data in parentheses indicate the correlation of a dichotomized variable with another variable.

Variables	*N*	Correlation	*p*-value
BMI/Skinfolds	39	.82	.001
BMI/BIA	39	.86	.001
BMI/Circum	39	.39(.33)	.01(.02)
Skinfolds/BIA	39	.87	.001
Skinfolds/Circum	39	.40(.28)	.01(.04)
BIA/Circum	39	.32(.32)	.02(.02)

Each of the four measures of body fat show a relationship with the remaining measures that was statistically significant beyond the .05 level. The correlations were weakest between Circumference and the remaining measures, but significant at the .04 or .02 levels.

Measures of Expenditure

These measures include Caltrac data and information from the Paffenbarger Survey that was transformed into caloric expenditure obtained from physical activity for six days.

Caltrac Total. For Days 1-3, data for four subjects were deleted because two subjects did not follow directions for wearing the Caltrac, one Caltrac broke and data were lost, and one subject reported data that were below RMR for 72 hr (RMR is the readout when the Caltrac is active but not worn). Of the remaining 35 subjects, readouts averaged 5186.49 (S.D. = 496.03). During Days 4-6, four

Caltracs stopped functioning, one subject did not follow directions, and several subjects were allowed to participate for three days only because of time constraints. The remaining 26 subjects' readouts averaged 4999 (S.D. = 353.9).

Caltrac/Hour. Subjects recorded the times they wore the Caltracs and it was apparent that some subjects were occasionally active during the day when they were not wearing the device. In order to obtain a more accurate estimate of expenditure when the Caltrac was worn, 4147 was subtracted from each subject's readout and the remainder was divided into the number of hours the Caltrac was worn for each 72-hr period. The number 4147 represents the metabolism for each Caltrac for 72 hr. This number was obtained by observing readouts of several devices that were activated simultaneously, and allowed to operate for several hours in a stationary position. Each device averaged .96 kcal/min.

For Days 1-3, average hourly rate for 36 subjects was 26.87 (S.D. = 13.07). For Days 4-6, average hourly rate for 27 subjects was 19.82 (S.D. = 6.55). For one subject, hourly rate was obtained although her data are not included in the Caltrac Total for Days 4-6 because her device broke and data were not available for the entire 72-hr period.

Paffenbarger Survey of Physical Activity. From the data listed in Table 1, estimates were made of weekly calories expended for stair climbing, walking, and active sports per week. Mean expenditure was 2163.36 kcal/week (S.D. = 1266.8).

Correlations of energy expenditure that are significant at or beyond the .05 level are listed:

Variables	*N*	Correlation	*p*-value
Caltrac1/Rate1	35	.91	.001
Caltrac2/Rate2	26	.90	.001
Caltrac1/Paffenbarger	35	.33	.03
Rate1/Paffenbarger	36	.39	.01

There was no correlation between Caltrac1 and Caltrac2 nor between Rate1 and Rate2. There was only a slight relationship between Caltrac2 or Rate2 and the Paffenbarger Survey ($r = .14$ and .22, respectively, N.S.). Pairwise *t*-tests between Caltrac1 and Caltrac2 were not significant ($t = 1.21$, df 24), nor were they significant between Rate1 and Rate2 ($t = 1.76$, df 25).

Weight Change Measures

As a part of the health questionnaire, subjects estimated amount of weight they had gained and lost over the past year. Weight change was analyzed two ways: (1) *Change.* This variable represents total number of pounds gained and lost in the past year; for example, if a subject gained and lost 20 lb, her Change would be 40 lb. (2) *Netwt.* In the example just given, the subject's net weight change in the past year would be zero.

Frequency distributions for Change and Netwt were not normal and Change was split into two categories: from 0-12 lb and from 13-57 lb. Netwt was recoded into three categories which were -28 through -2 lb, zero, and 3-22 lb. Before recoding, the correlation between Change and Netwt was .17 (N.S.); after recoding, the correlation was .36 ($p < .01$).

Body, Expenditure and Weight Measures

Correlations were computed for all variables with the following found significant at the .05 level or greater. Values in parentheses represent the correlation of a variable after it was recoded.

Variables	*N*	Correlation	*p*-value
	Activity Measures		
Rate1/Change	35	-.32(-.32)	.03(.03)
Caltrac2/BMI	26	-.47	.01
Caltrac2/Change	26	(.38)	(.03)
Rate2/BMI	27	-.38	.03
Rate2/Change	27	(.42)	(.02)

Variables	*N*	Correlation	*p*-value
	Body Measures		
Skinfolds/Netwt	38	.31(.34)	.03(.02)
Skinfolds/Change	38	.46	.001
BMI/Netwt	38	.29	.04
BMI/Change	38	.37	.01
BIA/Netwt	38	.28	.04
BIA/Change	38	.43	.001

The BMI variable has a negative correlation with Caltrac2 and Rate2 that is significant at the .01 or .03 levels. This means that, for those wearing the Caltrac for six days, the fatter the subjects as measured by BMI, the less active they were, according to Caltrac readouts from Days 4-6. Also, for those 27 subjects, the more active they were when they wore the Caltrac, the more labile had been their weight in the past year. The correlation between Rate2 and Change was only significant when Change was recoded. The correlation between Rate1 and Change was negative and the same whether or not Change was recoded. For the 35 subjects who wore the Caltrac for Days 1-3, the more active they were, as indicated by the Caltrac, the less labile had been their weight in the past year. The Skinfolds and Netwt correlation was slightly higher when Netwt was recoded, but the relationship between the two variables was significant either way. Significant correlations between Change and BMI, Skinfolds, and BIA were eliminated when Change was dichotomized. Similarly, Netwt had significant correlations with BMI and BIA before recoding, but they dropped out after recoding.

Discussion

In this experiment, measures of fatness including BMI, Skinfolds and BIA had highly significant relationships with each other, and they were comparable to those frequently found in laboratory research (Bray, 1986). Circumference measures are less widely used and their use has been restricted primarily to identify those at risk for CHD; however, McArdle et al. (1981) noted that subjects could be rank ordered according to fatness using circumference measures, and this has been the case in the present experiment, but to a lesser degree than using any of the other three measures of fatness. The results from this study suggest that as the waist increases in proportion to the hips, the more likely will that individual have a higher BMI value, and a greater percentage body fat. The relationship is not strong, however, indicating that a high waist-to-hip ratio may suggest fatness, but is not the sole determinant.

Measures of energy expenditure were Caltrac readouts for Days 1-3 and Days 4-6, and weekly calories expended as determined by transforming information on the Paffenbarger Survey into calories. If all subjects had followed instructions, they would have worn the Caltrac almost every waking moment for a three- or six-day period. Many subjects appeared to do this, but it was obvious that others were either approximating times worn or only wearing the device for a few hours each day. For example, some subjects consistently rounded off times to the hour and some subjects either spent an abnormal amount of time in bed or wore the device only during part of their waking hours. For these reasons, rate of activity per hour above RMR was calculated. The correlations for Caltrac1/Rate1 and Caltrac2/Rate2 were significant at less than .001.

There is a moderate, negative relationship between BMI and Caltrac2 (-.47) which is less significant when BMI is compared with Rate2 (-.38). When Caltrac1 or Rate1 is compared with BMI, however, the relationship is absent. It is possible that this seeming contradiction is due to small sample size, and it is also possible that the subjects who participated for only three days affected the data between Days 1-3 and Days 4-6 in some way that was different than subjects who participated for six days. In order to test this hypothesis, data for three-day-only subjects were eliminated and correlations were obtained only on the 26 subjects who participated for six days. The distribution for BMI was skewed (1.24) and leptokurtic (1.73) and was dichotomized so that BMI of 22.90 was included as the lowest value of the heavier BMIs (Appendix F). The value of 22.90 is the upper limit of Bray's (1986) "acceptable" classification for BMI, above which a woman would be considered overweight. This split also appeared to be a natural break between smaller and larger BMIs. Dichotomizing the data reduced skewness to .69, but kurtosis remained high and became negative (-1.66). The variables of BMI and Caltrac1 or Rate1 continued to show no relationship using either original or recoded BMI data, while the variables of

BMI and Caltrac2/Rate2 continued to show a relationship that was statistically significant.

Variable	Caltrac2	*p*-value	Rate2	*p*-value
BMI	-.45(-.36)	.01(.04)	-.36	.03

These data agree with Williams et al. (1989) who found poor reliability with the Caltrac when worn one day a week for three weeks. In the present experiment, there was no correlation between Caltrac1 and Caltrac2, or between Rate1 and Rate 2. Subjects began wearing the device at various days of the week, including weekends, and it would seem that if there were fluctuations in activity from day to day, there would be no trend toward increased or decreased activity. Average expenditure for Days 1-3 was 5186.49 kcal and for Days 4-6 was 4999 kcal, a decrease of about 187 kcal. The difference was more striking between Rates 1 and 2, with hourly expenditure decreased 7.05 kcal/hr during Days 4-6. Based on the Caltrac data, it would appear that subjects, on average, were more active during the first three days in which they wore the device than during the last three days. This suggests that subjects need a few days to become accustomed to the Caltrac before readout data are used for analysis.

In spite of the relationship between Caltrac2/Rate2 with BMI, no other measures of fatness were significantly related to the Caltrac, although Caltrac2 and Skinfolds approached significance (r=-.31, $p < .065$). The BMI is a measure of body weight that is not dependent on height and that has the highest correlation with body fat of all body weight measures. The BMI differs from fat measures in that it not only includes fatness in its calculation, it includes amount of lean tissue, bone structure and organ weight as well. Thus, BMI is a measure of overweight that includes fatness. This is why a heavily muscled, but lean, football player may have a BMI indicating overweight while the individual carries little fat. Similarly, a person who is heavier due to larger bone structure will have a higher BMI. Thus, BMI measures heaviness independent of height and dependent on other variables as well as fatness. According to the correlations found in this experiment, the heavier the subject, the less active she was during Days 4-6.

There was a significant positive correlation between Caltrac1/Rate1 and the Paffenbarger Survey that disappeared during Days 4-6. The Paffenbarger correlated with no measure of body fatness and, based on this small sample, data derived from the Paffenbarger do not predict fatness. It is possible that the Paffenbarger Survey provides an opportunity for heavier subjects to over-estimate their activity, similar to Curtis and Bradfield's (1971) study of overweight women in which activity was inaccurately recorded.

The experiments for this dissertation were conducted in a semi-rural area with few marked streets, and several subjects estimated that they walked only 2 or 3 city blocks a day. When possible, they were queried and, after some probing, usually raised their estimates. But it appeared that, overall, many subjects were unable to translate walking into blocks or fractions of miles. It is likely that Harvard alumni are older and generally more experienced with walking in cities; therefore, their walking estimates may be more accurate. For this reason, the Paffenbarger Survey was revised in the present study by eliminating calories expended from walking. The revised Paffenbarger Survey ("Paffrev") was then correlated with all previously analyzed variables.

The correlation between Caltrac1 and Paffrev was .34, significant at the .02 level. The correlation is almost the same as for Caltrac1 and Paffenbarger, but the correlation with Rate1 is higher ($r = .43$, $p < .004$). Paffrev has a high correlation with Paffenbarger ($r = .90$, $p < .001$) (see Appendix G) but correlated with no other variable except Caltrac1 and Rate 1. Weekly calories expended were estimated for stairs climbed ("Stairs") and sports activity ("Sports"), and there was a correlation between Sports and Rate1 ($r = .38$, $p < .01$). Sports and Paffenbarger had a high correlation ($r = .88$, $p < .001$), and Sports and Paffrev had an almost perfect correlation of .9669, but there was a zero correlation between Stairs and Paffenbarger or Paffrev. The distribution for Stairs was skewed (2.36) and leptokurtic (7.4) and was therefore dichotomized at the 51st percentile. Also, one student claimed to climb 50 flights of stairs a day and her data were removed. The recoded Stairs variable correlated with Caltrac1 ($r = .42$, $p < .01$) and Rate 1 ($r = .31$, $p < .04$), but Stairs still did not correlate with Paffenbarger or Paffrev. It would appear that in this experiment, active sports represented the Paffenbarger Survey better than either blocks walked or stairs climbed. None of the revisions to the original Paffenbarger data changed the relationship between the Paffenbarger Survey and Caltrac readouts for Days 1-3 and Days 4-6. Furthermore, these revisions did not increase correlations between the Paffenbarger Survey and measures of fatness.

The significant positive relationship between Skinfolds and Netwt indicates that amount of body fat changed as weight changed in these women. This relationship held whether or not Netwt was recoded. Intuitively, this is not surprising because most weight changes strongly affect amount of body fat.

The unrecoded distribution for Change correlated significantly with BMI ($r = .37$, $p < .01$), Skinfolds ($r = .46$, $p < .001$), and BIA ($r = .43$, $p < .001$). The only significant correlation Change had with any measure of activity was Rate1 ($r = -.32$, $p < .03$). Subjects whose weight fluctuated most were less active than subjects whose weight fluctuated least. Also, Change and fatness correlations imply that the more weight fluctuated, the fatter were the subjects. These correlations imply that fatter subjects were less active from Days 1-3, although there was no relationship between Caltrac1/Rate1 and measures of fatness, so it is likely that some thinner subjects were inactive while some fatter subjects were quite active regardless of weight fluctuations.

When the Change variable was recoded, there was no relationship between Change and measures of fatness. The negative correlation between Change and Rate1 held at the .03 significance level, but now there was a positive correlation between Change and Caltrac2 ($r = .38$, $p < .03$) and Rate2 ($r = .42$, $p < .02$). These data imply that the greater fluctuations in subjects' weights, the more active they were during Days 4-6, in contrast to Days 1-3 when they were less active. The most attractive explanation for this contradiction is that people whose weight fluctuates a great deal are more aware of their weight and may be more attentive to diet and activity. The Caltrac gave readouts that were in arbitrary numbers, and for the first three days, subjects had no standard with which to compare their readout. For Days 4-6, however, subjects could compare their activity with the first three days' readout, and the subjects with labile weights, perhaps best called "weight watchers," may have deliberately increased their activity. Because there was a significant negative correlation between BMI and Caltrac2/Rate2, indicating that fatter subjects were less active, it is concluded that weight watchers are not necessarily fat or thin, but are people with labile weight.

It is difficult to draw clear conclusions from the Change data because of the several disparate correlations. Fluctuating weight is an important issue in obesity research (Brownell et al., 1986) and it may be that people with unstable weight have unstable activity levels. Future research should examine this hypothesis. This experiment lends some support to the use of the Caltrac as an activity monitor, but if it is worn in field conditions where subjects are not supervised, data for the first few days should be discarded. Ideally, the Caltrac should be worn for several weeks to discern how activity fluctuates over time.

This, unfortunately, presents the problem of breakage and battery replacement. Of the original 20 devices, several broke for no apparent reason and almost one-half the Caltracs were returned for repair. Some of the repaired and other Caltracs broke in subsequent weeks. Replacement batteries are quite expensive and they are not long lasting. Each time a Caltrac's batteries were replaced, the cost ran to several dollars. It is hoped that the manufacturer can improve the quality of the devices so their use becomes less problematic.

Experiment 2

In order for a woman to reduce her body weight, she must make long-term changes in important areas of her life. The combination, in an unknown ratio, of genetics and environmental factors maintain one's weight at a particular level. Frequently, when the environment changes, weight also changes. Many subjects in Experiment 1 said they had gained several pounds during their first year at college, while others lost weight because they had to do more walking than they had done in high school. Whatever their previous activity level, being in a new environment had affected many subjects' lifestyle and, therefore, their weight.

Principles of behavior modification have valiantly attempted to present lifestyle alternatives that would ultimately produce weight loss in obese participants. Each principle has been translated into techniques that can be used by almost anyone. For example, the principle of stimulus control could encompass environmental changes such as keeping high-calorie food out of the house, putting a large bag of suet in the refrigerator representing the amount of fat one wishes to lose (Penick, Filion, Fox & Stunkard, 1974), and posting unattractive photographs of oneself at strategic points in the kitchen. While little analysis has been done of these individual components (see Johnson et al., 1980; Wilson & Brownell, 1980) to find out which interventions are important or trivial, overall, interventions which make even small lifestyle changes that would reduce body weight have not affected the overweight population in general.

The ultimate problem is that nothing may be more salient to the obese than the immediacy of good-tasting food, and because food cannot be foresworn for long periods of time, the obese must continually compromise between eating for enjoyment and eating out of necessity. As with exercise, the eating dilemma is one of self control, a choice between the small but immediate reinforcer as opposed to the larger but delayed reinforcer. Most, if not all, of the behavior management techniques for eating control are designed to delay the small, immediate reinforcer of tempting food. The assumption is that the person will become distracted by other environmental activities and will either forget about eating or discover she was not as hungry as she had seemed to be.

One way a person can distract herself from eating is to remind herself how well she is doing on her diet. Traditionally, she can reinforce this reminder by stepping on the scale and noting her progress. The scale has provided the most immediate feedback to the dieter because, ideally, she adjusts her intake according to the numbers on the scale. In this way, there is an interaction between the dieter and the scale in which each responds to the behavior of the other. If the dieter weighs herself frequently, she is frequently reminded of the adjustments she needs to make to attain more pleasing feedback from future weighings. Recording her weight and using the record as a constant reminder makes the feedback system even more salient.

Fisher, Green, Friedling, Levenkron and Porter (1976) prescribed daily weighing to 13 adults (4 males and 9 females). Daily weight was recorded by each subject on an individualized graph that was divided into daily segments for 30 days on the *x*-axis and starting weight at the top of the *y*-axis, with decreasing one-lb segments toward the origin, where current weight minus 12 lb was recorded. A diagonal line was drawn from the top of the *y*-axis to the far right-hand side of the *x*-axis, and subjects were told to try to keep their weight below the diagonal line. If they did this, they would be 12 lb lighter in 30 days. No further instructions and no reinforcers were given by the experimenters. Of the 11 participants who completed the study, the males lost an average of 15.5 lb and the females lost an average of 6.6 lb. The effects of this treatment were at least as good as found in many more elaborate weight-reduction programs, although there are no follow-up data on long-term maintenance.

Because body weight does not always reflect intake immediately and it is frequently inconvenient to weigh oneself throughout the day, the Caltrac can provide continuous feedback. Similarly, the waist cord devised by Simpson et al. (1986) is a constant reminder to the individual that he or she is trying to lose weight. When excess food is consumed, the expanding stomach causes discomfort where the waist contacts the cord. Several subjects did not wear the cord continuously, but one-third (14 subjects) of the group wore it for longer than one year and they continued to lose weight after treatment ended. Biofeedback mechanisms that keep dieters "on track" may be very useful in weight loss.

The accelerometer may be considered a biofeedback mechanism if it is worn by the overweight subject who programs it with his or her physical information so the instrument records typical expenditure for a person of that gender, age, height and weight. The Caltrac can also sum caloric intake and will calculate the difference between intake and output. Because the person knows at any moment if net expenditure is positive or negative, the Caltrac gives continuous information as to whether the person is gaining or losing weight and, for this reason, the Caltrac can be considered a biofeedback device.

There are apparently no studies to date testing the use of the Caltrac in controlled weight-loss studies. Brownell and Stunkard (1980) have stressed the importance of feedback in behavior modification for weight loss; and it is possible that the Caltrac may give feedback that is sufficiently reinforcing to maintain the individual in a negative energy balance. Just as exercise may serve as a specific cue for the individual to eat less and remain faithful to a dietary regimen (Brownell & Foreyt, 1985), making the individual constantly aware of energy balance may encourage dietary and exercise adherence. The purpose of Experiment 2 was to test the efficacy of the Caltrac as a weight-loss mechanism.

Method

Subjects

Twenty female students from the university were recruited through ads in campus newspapers and invitations proferred in psychology classes. Students in introductory psychology classes obtained laboratory credit for participation. Subjects were required to have at least 30 percent body fat as indicated by either skinfold measures or BIA; they were required to be between 18 and 30 years old, in good health, and could not be regular participants in sports that could damage the Caltrac. Almost all volunteers met these criteria.

Subjects joined treatment either individually or in small groups and agreed to participate for four weeks. At the first meeting, subjects signed consent forms (Appendix B), filled out the health questionnaire (Appendix A), answered the Paffenbarger Survey, and completed a ten-item survey developed by the experimenter to determine motivation to lose weight (Appendix H). Measures of weight and body fat were taken as described in Experiment 1, with the exception of BIA. In Experiment 1, there were wide variations in percent body fat between skinfold measures and BIA for individual subjects; also, recent research has questioned the accuracy of BIA as a measurement of body fat (see Baumgartner et al., 1990).

Subjects were randomly placed in one of two groups so that at least 15 subjects comprised the experimental group.

Group 1, Caltrac Group

Materials

Equipment. Each subject was given a Caltrac Personal Activity Computer®, a calorie-counting booklet, and a notebook in which to record all food eaten, amount and calorie count for four weeks.

Design and Procedure

Subjects were given detailed instructions on the use of the Caltrac (Appendix C2), which was programmed to estimate the total number of calories expended by each subject for the day by inputting height, weight, age and gender. In this manner, the basal metabolic rate was approximated and added to individual activity level. The formula is: Calories used = BMR + Activity level. Each subject's activity readout was affected by her individual program. Heavier subjects burned up calories faster for equivalent activity and this was reflected in higher Caltrac readouts. Subjects also input calories consumed and the difference between intake and output was seen on the "Net Cals" readout at any time. A negative readout indicated the number of intake calories that exceeded expenditure, and a positive readout indicated the number of expenditure calories that exceeded intake. The Caltrac was reset to zero at bedtime each night so the subject could begin each day with an excess of output calories. Subjects recorded Net Cals displayed by the Caltrac, and time of day the Caltrac was put on and removed each day.

All subjects were given a four-page synopsis of the literature review presented in Section I (Appendix I). They were asked to read the booklet and use any suggestions they found helpful.

Subjects met with the experimenter individually once a week in order to be weighed and discuss any problems relating to their progress. At the end of the study, all body measurements mentioned above were again taken.

Group 2, Weight-Graphing Group

Materials

Five subjects served. They were given individually designed weight graphs as described in Fisher et al. (1976). Each graph was pasted on a 4-1/4-in. x 5-1/2-in. sheet of light-weight cardboard. The top of the *y*-axis showed the subject's present weight plus 2 lb, "in order to 'prime' the user with initial success experiences," according to Fisher et al. A diagonal line, made of 1/16-in. red border tape was placed from the high weight at the top of the *y*-axis to the 28th day at the right-hand side of the *x*-axis.

Design and Procedure

Subjects were instructed to weigh themselves at the same time each day and to plot their weight on the graph daily. They were told to try to keep their weight below the diagonal. Subjects were also given calorie-counting booklets and small notebooks in which to record kind and amount of food eaten each day.

All subjects were given the literature synopsis and were asked to use any suggestions they found helpful. They met with the experimenter individually once a week in order to be weighed and discuss any problems relating to their progress. Body measurements were taken at the beginning and end of the study.

Results

Fifteen subjects participated in Group 1 (the Caltrac group), and 5 subjects participated in Group 2 (the weight-graphing group). Table 3 shows pre- and posttreatment weights for Group 1 and Group 2. Two subjects in Group 1 did not return for final measures and their weight and BMI are estimated from their last visit.

Independent *t*-tests were performed on $SPSS^{X}$ to test the difference between group means for pre-weight and for post-weight. Because of the unequal number of subjects in the two groups, variance was pooled. For Pre-weight differences, $t = .80$ (N.S.) and for Post-weight differences, $t = .31$ (N.S.). Subjects in Group 1 lost an average of .81 lb (S.D. = 3.43), with an average weekly weight change ranging from -1.05 to 1.25, indicating there was no systematic weight change across the duration of the experiment. Subjects in Group 2 gained an average of .7 lb (S.D. = 3.03). An independent *t*-test of the two means was not significant ($t = -.88$) and both groups were combined.

Table 3.
Pre- and posttreatment weight for Groups 1 and 2

Variable	Mean	S.D.	Median	Range
		Group 1		
Age	19.4	1.60	19.0	18-24
Height (in.)	64.77	2.68	64.25	60.25-70.00
Prewt (lb)	178.37	26.17	173.0	139-234
Postwt	177.13	25.24	170.0	142-231.5
		Group 2		
Age	18.8	0.45	19.0	18-19
Height (in.)	65.20	1.89	65.5	62-67
Prewt (lb)	167.7	24.25	170.0	134-192
Postwt	168.4	25.85	168.0	131-194

Table 4 shows measures of body fat, Change and Netwt for all subjects. There was virtually no difference between Pre- and PostBMI estimates, as weight loss for both groups combined was less than one-half lb (-.435, S.D. = 3.32). Postskinfolds have not been included in analysis because they were taken by two different people and the discrepancies between Pre- and Postskinfolds were too great to be usable. For example, one subject lost 3 lb but her suprailiac fold increased from 12 to 24 cm; another subject lost 1 lb and her anterior thigh was reduced 14 cm. Pre- and Postcircum measures were taken for 17 subjects and the waist-to-hip ratio was unchanged. For analysis, Circum before treatment was used.

Table 4.
Measures of body fat, Change and Netwt for Groups 1 and 2 combined (*N* = 20)

Variable	Mean	S.D.	Median	Range	Skew	Kurt.
Pre-BMI	29.35	4.0	27.6	24.51-38.35	.76	-.40
Post-BMI	29.24	4.0	27.6	23.96-37.94	.76	-.53
BMI Lost	-.11	.58	-.19	-1.55 to .96	-.38	.77
Preskinfolds	34.42	4.5	34.9	24.95-41.27	-.42	-.49
Circum	.78	.04	.78	.7-.85	-.48	-.69
Change	26.74	14.57	22	10-63	1.35	1.43
Netwt	3.37	13.04	0	-15 to 37	.93	.99
Wtlost	-.44	3.32	-.2	-9.5 to 5.0	-.85	1.72

Frequency distributions were computed for all measures and the distributions were considered normal if their skewness and kurtosis fell within the range of ±1. Change and amount of weight lost from pre- to posttreatment (Wtlost) failed to meet this criterion and they were recoded. Change was recoded into a dichotomy so that 10-22 lb became one group and 23-63 lb became a second group. Ten Change weights were in each group. Wtlost was split between subjects who lost weight (-.2 to -9.5) and subjects who either gained weight or whose weight did not change (0-5).

Pearson product-moment coefficients were computed for all variables before Change and Wtlost were recoded (Appendix J) and after recoding (Appendix K). Correlations significant beyond the .05 level are listed.

Variables	*N*	Correlation	*p*-value
	*Body Measures**		
PreBMI/PostBMI	20	.9895	<.001
Prewt/Postwt	20	.97	<.001
Prewt/PreBMI	20	.85	<.001
Prewt/Preskin	20	.79	<.001
PreBMI/Preskin	20	.73	<.001
PreBMI/Circum	20	-.46	.02
PostBMI/Circum	20	-.38	.05
Preskin/Circum	20	-.48	.02
BMIlost/Circum	19	.56	.007
Wtlost/Circum	20	.57	.005
Prewt/Circum	20	-.496	.01
Postwt/Circum	20	-.43	.03
Postwt/Paffenbarger	20	-.37	.05
	Weight change over past year		
Change/PreBMI	19	.42	.04
Change/PostBMI	19	.44	.03
Change/Netwt	19	.47	.02

*Correlations for Postwt with Pre- and PostBMI, and Preskin were all significant at $p < .001$ level. Correlations for PostBMI with Preskin and Prewt were significant at $p < .001$ level. Correlations for Postcircum and other variables are almost identical to correlations for Precircum and other variables.

Correlations

Pretreatment measures of weight and fat: BMI, Preskin, Circum and Prewt (weight of subjects before treatment) have moderate or high correlations with each other. Correlations of Circum with the other variables are negative, indicating that fatter, heavier subjects had lower waist-to-hip ratios than lighter, leaner subjects. This result is the opposite of that found in Experiment 1, in which heavier subjects had higher waist-to-hip ratios. The correlation between Pre- and PostBMI was almost perfect and the correlation between PreBMI and Preskin was almost the same as PostBMI and Preskin.

The relationship between weight and BMI was very strong, as was the relationship between weight and skinfolds. For these 20 subjects, body weight, skinfolds and BMI were closely related. Wtlost and Circum had a moderate correlation of .57 which indicates that the subjects with the higher waist-to-hip ratios lost the most weight. Although heavier subjects tended to have lower waist-to-hip ratios, there was no correlation between Wtlost and degree of overweight or fatness. There were no significant correlations between Wtlost and other variables when Wtlost was dichotomized. There was a strong relationship between Wtlost and BMIlost, and the BMIlost and Circum correlation was almost identical to Wtlost and Circum.

There was a negative correlation between Paffenbarger and Postwt that is significant at the .05 level and the correlation between Paffenbarger and Prewt was almost the same (-.36), with significance at the .06 level. Thus, there was a weak negative relationship between weight and activity level indicated on the Paffenbarger Survey.

Change shows a correlation with both Pre- and PostBMI that is significant at the .04 or .03 level, respectively, indicating that there is a trend for heavier subjects to have more labile weight. The more labile the weight, the greater the difference between present weight and weight one year ago. When Change was recoded to a dichotomous variable, significant correlations dropped out.

Motivation to Lose Weight Survey

Subjects rated ten statements (Table 5) on a scale from 1-7, with "1" signifying strong disagreement with the statement and "7" signifying strong agreement with the statement. Each statement was correlated with all variables previously examined and all statements were then correlated with each other. Correlations significant at the .05 level or beyond, 2-tailed, are listed following the table.

Table 5.
Motivation to Lose Weight Survey

1. I will do whatever is required of me to lose weight.
2. If this program fails to help me lose weight, I will give up trying.
3. I try most new diets I hear about.
4. If I am thinner I will be more popular with other women.
5. If I am thinner I will be more popular with men.
6. My mother is (was) overweight.
7. I was overweight when I was a child.
8. I enjoy good food.
9. I am willing to begin and maintain an exercise program for the rest of my life.
10. I eat between meals.

Variables	Correlation	*p*-value
Item 4/Prewt	.41	.04
Item 7/PreBMI	.47	.04
Item 7/Prewt	.60	<.001
Item 7/Wtlost	-.43	.04
Item 9/Paffenbarger	.44	.03
Item 3/Item 4	.52	.02
Item 3/Item 5	.50	.03
Item 4/Item 5	.76	<.001
Item 5/Item 6	.53	.02
Item 1/Item 9	.51	.03
Item 8/Item 10	.73	<.001

All correlations are moderate except those between Items 4 and 5, and Items 8 and 10 ($r = .76$ and .73, respectively), which are significant at <.001 level. Subjects rate popularity with men and women similarly, and the enjoyment of good food is related to amount of between-meal snacking. Item 7 is related to BMI and Prewt, and the correlations indicate that heavier subjects were more likely to have been overweight children and thus have been overweight most of their lives. There is a negative trend between the amount of weight lost and childhood obesity, in that the more weight subjects lost, the less likely they were overweight as children. Subjects with overweight mothers are more likely to relate thinness to increased popularity with men, and subjects who will not do whatever is required to lose weight are less likely to exercise.

Because there seems to be a relationship between Items 3, 4, 5 and 6, in that there were moderate correlations among these items, a Cronbach's *alpha* was performed to determine internal consistency of the four items. The *alpha* for the four items was .779, and this suggests that there is a fairly strong relationship between the variables of popularity with peers, dieting attempts, and Mother's obesity. Scores for Items 3-6 were summed for all subjects and a mean of 3.84 was obtained. Subjects were divided into two groups based on individual means for the four items. If their mean was above the grand mean, they were considered to have high motivation to lose weight; if their mean was below the grand mean, they were considered to have low motivation to lose weight. Eleven subjects were placed in the high-motivation group and eight subjects were in the low-motivation group (one subject did not complete the survey). A *t*-test (2-tailed) compared amount of weight lost between the two groups and was not significant ($t = -.20$, df 9.6).

Discussion

Ultimately, the test of effective weight-loss treatment is the amount of reduction in one or more body measures. In this experiment, neither weight, BMI, nor circumference was reduced. Subjects lost, on average, slightly less than one-half lb, BMI decreased one-tenth of a point, and circumference remained virtually unchanged.

The Weight-Graphing group was considered a control treatment to which the Caltrac results would be compared. All of the volunteers in the Fisher et al. study (1976) were friends or relatives of the experimenters or employees of the university where the research was conducted. The female volunteers lost considerably less weight than the males, but their average weight loss (6.6 lb) was greater than that in the present experiment (.7 lb gain). The age range in the Fisher et al. study was from 27-61 yr, making that group considerably older than the group in the present experiment. It is possible that the older subjects considered dieting more crucial to health and well-being than the younger subjects in the present experiment, many of whom did not appear fat or flabby, even though they were overweight.

Although the 15 subjects who wore the Caltrac were slightly more successful, by almost 2 lb, than subjects who graphed their weight, the Caltrac cannot be considered even marginally successful as a weight-loss device for this group. Some subjects said they were using the Caltrac properly and were surprised and disappointed when weighings did not show a noticeable weight loss. Other subjects admitted it was too easy to ignore the device when they were faced with fattening food. In other words, they were not "compelled" to record all calories, and they did not. The Caltrac is therefore a biofeedback device for those who use it as one; for others, it can be ignored when convenient.

Out of the 15 women who wore the device, 2 of them were successful. One subject lost 9.5 lb and another lost 5 lb. The latter subject was allowed to keep her Caltrac for an extra 3 mo and said she had lost a total of 16 lb. As with most weight loss treatments, the Caltrac was quite successful for a small percentage of subjects who used it. For the remaining subjects, however, the device was ineffective. As a result of this experiment, it can be concluded that the Caltrac is generally ineffective as a biofeedback device. Individuals may purchase the device and, for a few, it may help them lose weight. For group treatment, however, the Caltrac is not recommended. Unlike many other biofeedback devices, the Caltrac requires conscious attention from subjects. This is why it may be so ineffective.

Although it is unlikely that skinfold measures changed significantly, this experiment highlights the importance of having one skilled person measure body fat. Both persons performing the measurements were trained employees of the physical education department, yet the differences in site and amount of skin taken up by the calipers was so discrepant between the two technicians at the post-treatment measurements, the results were unusable.

As indicated by the correlations between BMI or Skinfolds and Circumference, subjects with the lowest waist-to-hip ratio tended to be heavier than those with higher ratios; in other words, the heavier subjects had gynoidal or "female"-type obesity, which is frequently associated with hypercellularity and childhood-onset obesity (Bray, 1989). These subjects lost less weight than those who had higher waist-to-hip ratios; the correlation between BMIlost and Circumference is .56, indicating the more androidal or "male"-type obesity, the more successful was the weight loss. Subjects who said they were overweight children tended to be heavier ($r = .60$, $p < .007$, 2-tailed) and they also tended to have female obesity because of their proportionally larger hips; they lost less weight; and they may have been more hypercellular than the thinner subjects. If this is so, prognosis for future successful weight loss for these subjects is poor. Circumference measures may be a good way to predict weight-loss success in future studies.

The Motivation Survey suggests some tentative conclusions as a result of several correlations. There was a fairly strong relationship between enjoyment of good food and snacking ($r = .73$, $p < .000$, 2-tailed). A successful long-term weight loss regimen should probably include several small daily meals rather than three larger meals with no snacking. This is in agreement with Fábry and Tepperman's (1970) study of boarding school students in which students who ate five or seven meals a day were, on average, thinner than those who ate only three meals a day.

Subjects did not discriminate between popularity with males and with females. Weight loss, they claimed, would have the same effect on popularity with either gender. There is a relationship between the number of diets attempted and perceived popularity, with the more effect being thin is seen to have on popularity, the more subjects attempt to lose weight. The relationship between Mother's obesity and popularity with men was significant. It is difficult to interpret this correlation, but perhaps subjects tend to see a strain in the obese mother's relationships with men including, perhaps, her spouse, that is reflected in the subjects' relationships with men in their own lives.

The fairly strong Cronbach's *alpha* of .779, which tested reliability among the items for popularity, Mother's obesity and dieting attempts, indicates that these items seem to test a similar underlying variable. It is not surprising that in western culture, where thinness seems to predispose popularity, subjects in the present study would draw similar conclusions. Motivation to lose weight was interpreted in this dissertation as high scores on Mother's obesity, popularity, and dieting attempts. The eleven subjects rated as having high motivation did not lose significantly more weight than those subjects rated as having low motivation. It is likely that motivation or desire to lose weight is seldom carried out in actual weight loss.

Finally, motivation to do anything to lose weight was related to motivation to exercise, but this did not seem to be related to weight lost. Perhaps motivation to lose weight that is determined by a test or survey reflects a behavior that is not the same as the behavior of losing weight.

General Discussion

This dissertation attempted to answer two questions: (1) Does a relationship exist between body weight and fat, and activity that can be shown by either the Caltrac Personal Activity Computer® or the Paffenbarger Survey of Activity; and (2) Can the Caltrac be useful as a biofeedback device for weight loss? The answer to the first question is perhaps "Yes"; the answer to the second question is definitely "No."

Experiment 1 indicates poor test-retest reliability for the Caltrac because readouts for many subjects changed so drastically from the first three-day period to the second three-day period. This conclusion is in accord with that of Williams et al. (1989) who found no reliability from week to week when the device was worn one day a week. In Experiment 1 of this dissertation, 16 out of 39 subjects had Caltrac readings that were within 100 points between the first and second three-day periods. The remaining subjects either had changing activity levels or deliberately manipulated activity during one of the two periods. Because BMI correlated significantly with the second three-day readouts, it has been assumed this period more accurately reflects typical activity.

Of greater concern are the results of the Nichols et al. study (1990) in which effectiveness of the Caltrac dissipated in older subjects and when individual indirect calorimetry was correlated with the Caltrac. The study strongly suggests that the Caltrac may inaccurately reflect activity for individual subjects and any correlations obtained could be spurious.

The use of the Caltrac in weight-loss studies is limited at best. It may be useful for individuals to learn how active they are, but this seems unnecessary if a person is overweight. Learning that one is "sufficiently active" or "active enough," if there were such a standard, will not solve the problem and the individual is still left with the dilemma of increasing output and decreasing intake. The attractiveness of the Caltrac for weight loss is that it can be used by indi-viduals to calibrate their own intake and output, regardless of whether they eat too much, exercise too little, or both. It is possible that when subjects learned how much they had to reduce intake in proportion to output, they became discouraged and stopped using the device. It is also possible they under-estimated intake. A few subjects complained that their Caltrac showed a negative balance every day, yet they did not lose weight.

In light of some Caltrac tests, it is possible that this device is neither a valid (see Nichols et al., 1990) nor a reliable measure of activity (see Williams et al., 1989). The Nichols et al. study was especially troubling because there were extreme differences in readouts that were a function of age. It is difficult to speculate why there would be differences in readouts from Caltracs that were placed on backs of subjects, but if age is a factor, perhaps shape is also a factor that prevents accurate measurement of activity. Laboratory tests correlating the Caltrac and indirect calorimetry need to address this question. If the Caltrac overestimates activity by some small number of calories, subjects will assume they are in negative energy balance when they may be, in fact, in positive balance.

The loss of a single pound requires a deficit of 3500 or so calories; a negative balance of 500 kcal/day will result in only a 1 lb weekly loss. If the individual has one "bad" day in the week, she will show no weight loss at all. It is possible that many subjects in Experiment 2 reduced intake most of the time but had occasional lapses that negated previous efforts.

The Caltrac is a biofeedback device as long as it is properly used. Even so, consequences of positive energy balance, according to the display, are no more powerful than the consequences of seeing an undesirable weight on a scale. One may be unhappy and vow to do better tomorrow, but the ability of the scale to stop excessive intake is obviously limited, and this also seems to be true of the Caltrac.

Little research has tested differences in adherence to treatment between very young adults and older adults, but it is possible the device may be more effective with an older population or with males. Nevertheless, it was disappointing that the Caltrac did not help the two subjects who were very obese and weighed considerably over 200 lb, with body fat that approached or exceeded 40 percent.

It is likely that each person follows patterns of intake and output that have existed for many years. Intake and output may vary over several days but, overall, is unchanging. When one attempts to disrupt this balance, physiological mechanisms, such as set point, intervene to re-establish the ratio. It may be of greater value for organisms to maintain unchanging intake-output ratios than to maintain a balance that is aesthetically pleasing or even healthier, if such a balance cannot be maintained over long time.

Maintaining the intake-output ratio must rely heavily on the reinforcement value of food to the individual. It is possible that good food is the most frequently used reinforcer by overweight people. Reducing an abundance of good-tasting food means thinning the individual's schedule of reinforcement. Voluntary reduction of a reinforcer may be impossible unless it is replaced by another equally strong reinforcer. The penitent may forego dessert or life itself in return for the promise of eternal bliss, but the penitent won't give up a crumb without a favorable return.

Several people in the Simpson et al. study (1986) lost considerable weight and maintained the loss. For those people, the consequence of overeating was immediate and physiologically unpleasant. The waist cord is always around one's middle and cannot be ignored unless the cord is cut. As a result, finishing the cheesecake is not as important as preventing further discomfort. Further research needs to be done in order to evaluate large-scale use of the waist cord.

Whereas the Caltrac may be ineffective for monitoring intake, it may be an appealing way to increase expenditure by very small steps. If an individual increases output in perhaps 10-kcal/day increments, this kind of behavior shaping might be acceptable, especially when meeting a daily goal is followed by a reinforcer. Thus, the waist cord and the Caltrac might be an attractive and effective combination that could promote and maintain weight loss. An application of both devices at the same time may solve the dual problem of decreasing intake while increasing expenditure.

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APPENDICES

APPENDIX A

Health Questionnaire for Women

Name ____
Date of Birth ______________________________ Age ____________
Phone _________________________ Message _________________
Address ____
Date Last Menstrual Period Began ______________________________
Date Next Menstrual Period Due _______________________________
About how many days is your menstrual cycle? ______________________
Are you diabetic (yes/no) ____________ Thyroid problems? __________
Do you have asthma? _______________
Do you have orthopedic-related (bone) problems? ____________________
Are you now or formerly married: ___________ For how long? ________
Have you ever had a baby? ____________________ If so, how many children have you had and what are their ages? _____________________
What medication do you take? ________________________________
Do you take birth-control pills? ______ _________________________
How many times a year do you get sick (including colds/flu)? ______ ______
Do you have any physical condition that would classify your health as anything other than excellent? _______________________________________
How do you perceive the level of stress in your life?
Low 1 2 3 4 5 6 7 High
How do you rate your daily energy level?
Low 1 2 3 4 5 6 7 High
About how many hours per night do you sleep? _____________________
How much alcohol do you consume each week?
_____ bottles of beer _____ glasses of wine Other: ______________
Do you smoke cigarettes? Yes _____ No _____ # Per day _________
How much coffee, tea or caffeinated drinks do you consume/day?
Comments:

APPENDIX B

Informed Consent Form

1. I understand that this research project has been approved by the University of New Hampshire Institutional Review Board (IRB) and that it has authorized the use of human subjects to participate in it.
2. I understand the scope, aims, and purposes of this research project and the procedures to be followed (including identification of any treatments or procedures which are experimental) and the expected duration of my participation.
3. I have received a description of any reasonable foreseeable risks or discomforts associated with my being a subject in this research, have had them explained to me, and understand them.
4. I have received a description of any potential benefits that may be accrued from this research and understand how they may affect me or others.
5. I understand that the confidentiality of all data and records associated with my participation in this research including my identity, will be fully maintained within the extent of the law.
6. I understand that I have the right to ask any questions concerning this research, related subjects, and my participation in it, and to have such questions answered by the investigator.
7. I understand that my consent to participate in this research is entirely voluntary, and that my refusal to participate will involve no prejudice, penalty, or loss of benefits to which I would otherwise be entitled.
8. I understand that if I consent to participate, I may discontinue my participation at any time without prejudice, penalty, or loss of benefits to which I would be otherwise entitled.
9. I confirm that no coercion of any kind was used in seeking my participation in this research project.
10. I understand that if hospitalization or any other form of professional attention becomes necessary as a result of my participation, none of the expenses will be borne by the University of New Hampshire.
11. I understand that if I have any questions pertaining to my participation in this project, I may call Sandy Rutter at 862-2360 (office) or 868-xxxx (home) and be given the opportunity to discuss them in confidence.
12. I understand that I will not be provided financial compensation for my participation by the University of New Hampshire.
13. I understand that any information gained about me as a result of my participation will be provided to me at the conclusion of my involvement in this research project.
14. I understand that if I lose the Caltrac device or damage it due to carelessness or negligence I will not receive laboratory credit for participation.
15. I certify that I have read and fully understand the purpose of this research project and its risks and benefits for me as stated above.

I, ______________________________ CONSENT/AGREE to participate.

APPENDIX C1

Instructions for Caltrac Use

INSTRUCTIONS TO CALTRAC PARTICIPANTS IN ACTIVITY STUDY
Sandy Rutter - Department of Psychology

This study will examine activity in undergraduate women at the University of New Hampshire. You will be given a device, called a "Caltrac," that will monitor your activity during waking hours for 6 days. There are some do's and don'ts for you to follow in order to keep the Caltrac working properly.

IMPORTANT

If you are due to have a menstrual period in the next seven days, you must be rescheduled. You must not wear the Caltrac during the day before or the first 2 days of your period. If this is a problem, you can be rescheduled.

1. Don't drop, throw, jar or otherwise subject the device to rough handling.

2. Don't get the device wet. Don't wear the Caltrac in water, and make sure it is covered if you wear it out in the rain.

3. Put the Caltrac on your right hip (if you are right-handed) or your left hip (if you are left handed) as soon as you get up in the morning. For the 6 days in which you wear the device, you may have to modify a few dress habits. For example, you need to have something on in the morning to which the Caltrac can be attached at the hip. Also, this is not a good time to wear expensive dresses that have no loops or hooks with which you can attach the device.

4. Leave the Caltrac on until you go to bed, except for bathing and swimming. Remember to switch the device to new clothing if you change during the day.

5. Please write down the time of day you put on the device and the time you take it off. Do this each day you wear the Caltrac.

6. If you forget to wear the Caltrac, record the amount of time you left it off. This is very important. We will obtain inaccurate data if we think you wore the device all the time when you didn't.

7. In order to practice wearing the device, put it on now and wear it for the rest of the day. Your Caltrac has been pretested, but it may not record your activity properly. You may notice this and should call me at once. I will give you a replacement.

8. Tonight, reset the counter to zero. Don't record time worn today. Record your time beginning tomorrow.

9. Wear the Caltrac for 3 full days. Do NOT reset the device after tonight and do NOT record the readout. On the third night in which you wear the device, call me before you go to bed with your readout. Immediately reset the device to zero and wear it for another 3 days.

10. On the 6th night, call me before you go to bed and tell me the readout.

11. Return the device the next day to the psychology office. Make sure the secretary knows you returned the device and has your name. Give the secretary your time sheet with your name on it.

12. I will call you to arrange our meeting in Physical Education for body measurements. When you come to PE, bring a pair of shorts and wear a loose, short-sleeved T-shirt. In order for accurate measurements, you must abstain from drinking any alcohol for 24 hours before the measurements are taken. You must also not eat any food or drink anything except water for four hours before the measurements are taken. Finally, please do not engage in any exercise on the day in which the measurements are taken.

REMEMBER: Reset the device ONLY tonight and at the end of Day 3 (Day 1 is tomorrow). Do NOT reset the device at any other time.

APPENDIX C2

Instructions for Caltrac Use

INSTRUCTIONS TO CALTRAC PARTICIPANTS IN WEIGHT-LOSS STUDY
Sandy Rutter - Department of Psychology

This study will make use of some new techniques for weight loss in females who are at least ten percent over normal body fat. This means at least 30 percent of your body mass must be fat. You will be given a device, called a "Caltrac," that will monitor your activity during waking hours. There are some do's and don'ts for you to follow in order to keep the Caltrac working properly, and you must follow some simple instructions each day while you are in the experiment.

1. Don't drop, throw, jar or otherwise subject the device to ugh handling.

2. Don't get the device wet. Don't wear the Caltrac in water, and make sure it is covered if you wear it out in the rain.

3. Put the Caltrac on your right hip (if you are right-handed) or your left hip (if you are left handed) as soon as you get up in the morning. For the 6 days in which you wear the device, you may have to modify a few dress habits. For example, you need to have something on in the morning to which the Caltrac can be attached at the hip. Also, this is not a good time to wear expensive dresses that have no loops or hooks with which you can attach the device.

4. Leave the Caltrac on until you go to bed, except for bathing and swimming. Remember to switch the device to new clothing if you change during the day.

5. Please write down the time of day you put on the device and the time you take it off. Do this each day you wear the Caltrac.

6. If you forget to wear the Caltrac, record the amount of time you left it off. This is very important. We will obtain inaccurate data if we think you wore the device all the time when you didn't.

7. In order to practice wearing the device, put it on now and wear it for the rest of the day. Your Caltrac has been pretested, but it may not record your activity properly. You may notice this and should call me at once. I will give you a replacement.

8. When you go to bed, reset the device by pressing SHIFT and CLEAR at the same time. When you take off the Caltrac at night, write down your energy balance by recording the number for "NET CALS." Follow this routine every day

for the 28 days in which you wear the device. Be sure you write down the time you put on the device and the time you remove it.

9. You have been given a small calorie-counting booklet. Keep it with you as well as your notebook and record your food intake every time you eat. You should record your intake in the notebook AND you should add it to the Caltrac by pressing SHIFT and CALS IN at the same time. The readout will say: "CALS IN?" You will press the UP key (don't shift) until you have entered the appropriate number of calories. You can adjust the entry by pressing DOWN if you overshoot the calories. When you have entered the exact amount of calories you just ate, press ENTER. The Caltrac will now record what you have eaten and subtract that amount from your NET CALS automatically.

10. We will arrange to meet once a week at which time you will bring your notebook that will have the "Calories Used" for each day of the preceding week. A sample notebook page should look like this:

Date	Time on	Time off	Cals used
02/15	8:20 a.m.	11:45 pm	+180

ITEM	CALS
8 oz orange juice	110
2 sl. toast (w/w)	160
2 T butter	200
etc.	

11. I will call you at the end of the fourth week to arrange our meeting in Physical Education for body measurements. When you come to PE, bring a pair of shorts and wear a loose, short-sleeved T-shirt. In order for accurate measurements, you must abstain from drinking any alcohol for 24 hours before the measurements are taken. You must also not eat any food or drink anything except water for four hours before the measurements are taken. Finally, please do not engage in any exercise on the day in which the measurements are taken.

APPENDIX D

Pearson Product-Moment Correlations -- Experiment 1

27-Jun-90 SPSS-X RELEASE 3.1 FOR VAX/VMS
18:01:59 SPSS-X 3.12 VAX/VMS UNH on UNHH:: VMS V5.3

- - - - - - - - - - - - - - - P E A R S O N   C O R R E L A T I O N   C O E F F I C I E N T S - - - - - - - - - - - - - - -

	BMI	SKIN	BIO	CAL1	CAL2	RATE1	RATE2	CIRCUM	PAFF	CHANGE	NETWT
BMI	1.0000 (39) P= .	.8231 (39) P= .000	.8568 (39) P= .000	-.0930 (35) P= .298	-.4728 (26) P= .007	-.1503 (36) P= .191	-.3789 (27) P= .026	.3883 (39) P= .007	.1063 (39) P= .260	.3691 (38) P= .011	.2853 (38) P= .041
SKIN	.8231 (39) P= .000	1.0000 (39) P= .	.8703 (39) P= .000	-.0086 (35) P= .480	-.3052 (26) P= .065	-.0826 (36) P= .316	-.2253 (27) P= .129	.4023 (39) P= .006	-.0605 (39) P= .357	.4610 (38) P= .002	.3050 (38) P= .031
BIO	.8568 (39) P= .000	.8703 (39) P= .000	1.0000 (39) P= .	-.0397 (35) P= .410	-.2300 (26) P= .129	-.1444 (36) P= .200	-.1480 (27) P= .231	.3223 (39) P= .023	.0702 (39) P= .336	.4314 (38) P= .003	.2830 (38) P= .043
CAL1	-.0930 (35) P= .298	-.0086 (35) P= .480	-.0397 (35) P= .410	1.0000 (35) P= .	-.0275 (25) P= .448	.9128 (35) P= .000	.0460 (26) P= .412	.0595 (35) P= .367	.3337 (35) P= .025	-.2068 (34) P= .120	.0102 (34) P= .477
CAL2	-.4728 (26) P= .007	-.3052 (26) P= .065	-.2300 (26) P= .129	-.0275 (25) P= .448	1.0000 (26) P= .	-.1051 (25) P= .309	.8957 (26) P= .000	-.2319 (26) P= .127	.1427 (26) P= .243	.2972 (26) P= .070	-.2779 (26) P= .085
RATE1	-.1503 (36) P= .191	-.0826 (36) P= .316	-.1444 (36) P= .200	.9128 (35) P= .000	-.1051 (25) P= .309	1.0000 (36) P= .	.0083 (26) P= .484	.1152 (36) P= .252	.3934 (36) P= .009	-.3193 (35) P= .031	.0085 (35) P= .481
RATE2	-.3789 (27) P= .026	-.2253 (27) P= .129	-.1480 (27) P= .231	.0460 (26) P= .412	.8957 (26) P= .000	.0083 (26) P= .484	1.0000 (27) P= .	-.0506 (27) P= .401	.2218 (27) P= .133	.0456 (27) P= .411	-.4057 (27) P= .018
CIRCUM	.3883 (39) P= .007	.4023 (39) P= .006	.3223 (39) P= .023	.0595 (35) P= .367	-.2319 (26) P= .127	.1152 (36) P= .252	-.0506 (27) P= .401	1.0000 (39) P= .	.1345 (39) P= .207	.1152 (38) P= .245	-.0739 (38) P= .330
PAFF	.1063 (39) P= .260	-.0605 (39) P= .357	.0702 (39) P= .336	.3337 (35) P= .025	.1427 (26) P= .243	.3934 (36) P= .009	.2218 (27) P= .133	.1345 (39) P= .207	1.0000 (39) P= .	-.1614 (38) P= .167	.0180 (38) P= .457
CHANGE	.3691 (38) P= .011	.4610 (38) P= .002	.4314 (38) P= .003	-.2068 (34) P= .120	.2972 (26) P= .070	-.3193 (35) P= .031	.0456 (27) P= .411	.1152 (38) P= .245	-.1614 (38) P= .167	1.0000 (38) P= .	.1676 (38) P= .157
NETWT	.2853 (38) P= .041	.3050 (38) P= .031	.2830 (38) P= .043	.0102 (34) P= .477	-.2779 (26) P= .085	.0085 (35) P= .481	-.4057 (27) P= .018	-.0739 (38) P= .330	.0180 (38) P= .457	.1676 (38) P= .157	1.0000 (38) P= .

(COEFFICIENT / (CASES) / 1-TAILED SIG) " . " IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED

APPENDIX E

Pearson Product-Moment Correlations with Skewed and Leptokurtic Variables Recoded -- Experiment 1

SPSS-X RELEASE 3.1 FOR VAX/VMS
SPSS-X 3.12 VAX/VMS UNH on UNHH:: VMS V5.3

- - - - - - - - - P E A R S O N C O R R E L A T I O N C O E F F I C I E N T S - - - - - - - - - - - - -

	BMI	SKIN	BIO	CAL1	CAL2	RATE1	RATE2	CIRCUM	PAFF	CHANGE	NETWT
BMI	1.0000 (39) P= .	.8231 (39) P= .000	.8568 (39) P= .000	-.0930 (35) P= .298	-.4728 (26) P= .007	-.1503 (36) P= .191	-.3789 (27) P= .026	.3331 (39) P= .019	.1063 (39) P= .260	.0681 (38) P= .342	.2020 (38) P= .112
SKIN	.8231 (39) P= .000	1.0000 (39) P= .	.8703 (39) P= .000	-.0086 (35) P= .480	-.3052 (26) P= .065	-.0826 (36) P= .316	-.2253 (27) P= .129	.2845 (39) P= .040	-.0605 (39) P= .357	.2249 (38) P= .087	.3351 (38) P= .020
BIO	.8568 (39) P= .000	.8703 (39) P= .000	1.0000 (39) P= .	-.0397 (35) P= .410	-.2300 (26) P= .129	-.1444 (36) P= .200	-.1480 (27) P= .231	.3231 (39) P= .022	.0702 (39) P= .336	.2446 (38) P= .069	.2461 (38) P= .068
CAL1	-.0930 (35) P= .298	-.0086 (35) P= .480	-.0397 (35) P= .410	1.0000 (35) P= .	-.0275 (25) P= .448	.9128 (35) P= .000	.0460 (26) P= .412	.0724 (35) P= .340	.3337 (35) P= .025	-.1849 (34) P= .148	.0076 (34) P= .483
CAL2	-.4728 (26) P= .007	-.3052 (26) P= .065	-.2300 (26) P= .129	-.0275 (25) P= .448	1.0000 (26) P= .	-.1051 (25) P= .309	.8957 (26) P= .000	.0563 (26) P= .392	.1427 (26) P= .243	.3771 (26) P= .029	.2075 (26) P= .155
RATE1	-.1503 (36) P= .191	-.0826 (36) P= .316	-.1444 (36) P= .200	.9128 (35) P= .000	-.1051 (25) P= .309	1.0000 (36) P= .	.0083 (26) P= .484	.0379 (36) P= .413	.3934 (36) P= .009	-.3156 (35) P= .032	-.0844 (35) P= .315
RATE2	-.3789 (27) P= .026	-.2253 (27) P= .129	-.1480 (27) P= .231	.0460 (26) P= .412	.8957 (26) P= .000	.0083 (26) P= .484	1.0000 (27) P= .	.1671 (27) P= .202	.2218 (27) P= .133	.4193 (27) P= .015	.0924 (27) P= .323
CIRCUM	.3331 (39) P= .019	.2845 (39) P= .040	.3231 (39) P= .022	.0724 (35) P= .340	.0563 (26) P= .392	.0379 (36) P= .413	.1671 (27) P= .202	1.0000 (39) P= .	.1584 (39) P= .168	.2632 (38) P= .055	-.0597 (38) P= .361
PAFF	.1063 (39) P= .260	-.0605 (39) P= .357	.0702 (39) P= .336	.3337 (35) P= .025	.1427 (26) P= .243	.3934 (36) P= .009	.2218 (27) P= .133	.1584 (39) P= .168	1.0000 (39) P= .	-.0455 (38) P= .393	-.1299 (38) P= .219
CHANGE	.0681 (38) P= .342	.2249 (38) P= .087	.2446 (38) P= .069	-.1849 (34) P= .148	.3771 (26) P= .029	-.3156 (35) P= .032	.4193 (27) P= .015	.2632 (38) P= .055	-.0455 (38) P= .393	1.0000 (38) P= .	.3579 (38) P= .014
NETWT	.2020 (38) P= .112	.3351 (38) P= .020	.2461 (38) P= .068	.0076 (34) P= .483	.2075 (26) P= .155	-.0844 (35) P= .315	.0924 (27) P= .323	-.0597 (38) P= .361	-.1299 (38) P= .219	.3579 (38) P= .014	1.0000 (38) P= .

(COEFFICIENT / (CASES) / 1-TAILED SIG) " . " IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED

APPENDIX F

Pearson Product-Moment Correlations (After Recoding) of Variables for 26 Subjects Who Participated for Six Days -- Experiment 1

SPSS-X RELEASE 3.1 FOR VAX/VMS
SPSS-X 3.12 VAX/VMS UNH on UNHH:: VMS V5.3

- - - - - - - - P E A R S O N C O R R E L A T I O N C O E F F I C I E N T S - - - - - - - - - - - - - -

	BMI	SKIN	BIO	CAL1	CAL2	CIRCUM	RATE1	RATE2	PAFF	CHANGE	NETWT
BMI	1.0000 (26) P= .	.7388 (26) P= .000	.6865 (26) P= .000	-.1532 (26) P= .228	-.3597 (25) P= .039	.5173 (26) P= .003	-.1475 (26) P= .236	-.2628 (26) P= .097	.1644 (26) P= .211	.0249 (26) P= .452	.3763 (26) P= .029
SKIN	.7388 (26) P= .000	1.0000 (26) P= .	.8611 (26) P= .000	.0684 (26) P= .370	-.2822 (25) P= .086	.3651 (26) P= .033	.0960 (26) P= .320	-.2102 (26) P= .151	.0546 (26) P= .396	.2451 (26) P= .114	.5598 (26) P= .001
BIO	.6865 (26) P= .000	.8611 (26) P= .000	1.0000 (26) P= .	-.0326 (26) P= .437	-.1984 (25) P= .171	.2499 (26) P= .109	-.0732 (26) P= .361	-.1272 (26) P= .268	.1254 (26) P= .271	.3383 (26) P= .045	.6047 (26) P= .001
CAL1	-.1532 (26) P= .228	.0684 (26) P= .370	-.0326 (26) P= .437	1.0000 (26) P= .	-.0275 (25) P= .448	.1493 (26) P= .233	.9001 (26) P= .000	.0460 (26) P= .412	.1873 (26) P= .180	-.1266 (26) P= .269	-.0858 (26) P= .338
CAL2	-.3597 (25) P= .039	-.2822 (25) P= .086	-.1984 (25) P= .171	-.0275 (25) P= .448	1.0000 (25) P= .	-.2338 (25) P= .130	-.1051 (25) P= .309	.8940 (25) P= .000	.1240 (25) P= .277	.3489 (25) P= .044	-.2726 (25) P= .094
CIRCUM	.5173 (26) P= .003	.3651 (26) P= .033	.2499 (26) P= .109	.1493 (26) P= .233	-.2338 (25) P= .130	1.0000 (26) P= .	.2872 (26) P= .077	-.0506 (26) P= .403	.2990 (26) P= .069	.0012 (26) P= .498	-.0632 (26) P= .379
RATE1	-.1475 (26) P= .236	.0960 (26) P= .320	-.0732 (26) P= .361	.9001 (26) P= .000	-.1051 (25) P= .309	.2872 (26) P= .077	1.0000 (26) P= .	.0083 (26) P= .484	.2189 (26) P= .141	-.1918 (26) P= .174	-.0922 (26) P= .327
RATE2	-.2628 (26) P= .097	-.2102 (26) P= .151	-.1272 (26) P= .268	.0460 (26) P= .412	.8940 (25) P= .000	-.0506 (26) P= .403	.0083 (26) P= .484	1.0000 (26) P= .	.2107 (26) P= .151	.3751 (26) P= .030	-.4048 (26) P= .020
PAFF	.1644 (26) P= .211	.0546 (26) P= .396	.1254 (26) P= .271	.1873 (26) P= .180	.1240 (25) P= .277	.2990 (26) P= .069	.2189 (26) P= .141	.2107 (26) P= .151	1.0000 (26) P= .	.0764 (26) P= .355	-.0613 (26) P= .383
CHANGE	.0249 (26) P= .452	.2451 (26) P= .114	.3383 (26) P= .045	-.1266 (26) P= .269	.3489 (25) P= .044	.0012 (26) P= .498	-.1918 (26) P= .174	.3751 (26) P= .030	.0764 (26) P= .355	1.0000 (26) P= .	.1210 (26) P= .278
NETWT	.3763 (26) P= .029	.5598 (26) P= .001	.6047 (26) P= .001	-.0858 (26) P= .338	-.2726 (25) P= .094	-.0632 (26) P= .379	-.0922 (26) P= .327	-.4048 (26) P= .020	-.0613 (26) P= .383	.1210 (26) P= .278	1.0000 (26) P= .

APPENDIX G

Pearson Product-Moment Correlations of Paffenbarger Survey Data with "Blocks" Removed -- Experiment 1

	PAFFREV	STAIRS	SPORTS
BMI	.0047 (39) P= .489	.0860 (39) P= .301	-.0174 (39) P= .458
SKIN	-.1222 (39) P= ..229	.0969 (39) P= .279	-.1454 (39) P= .189
BIO	-.0561 (39) P= .367	-.0070 (39) P= .483	-.0535 (39) P= .373
CAL1	.3427 (35) P= .022	.2704 (35) P= .058	.2620 (35) P= .064
CAL2	.1238 (26) P= .273	.0298 (26) P= .443	.1140 (26) P= .290
RATE1	.4345 (36) P= .004	.1834 (36) P= .142	.3787 (36) P= .011
RATE2	.2503 (27) P= .104	-.0665 (27) P= .371	.2714 (27) P= .085
CIRCUM	.0484 (39) P= .385	-.0179 (39) P= .457	.0523 (39) P= .376
PAFF	.8956 (39) P= .000	.0076 (39) P= .482	.8817 (39) P= .000
CHANGE	.0301 (38) P= .429	-.1836 (38) P= .135	.0766 (38) P= .324
NETWT	-.0365 (38) P= .414	.2897 (38) P= .039	-.1100 (38) P= .255

(COEFFICIENT / (CASES) / 1-TAILED SIG)

APPENDIX H

Motivation to Lose Weight Survey

Name ______________________________ Date ________________

Please answer the following questions on a scale from 1 - 7:

1. I will do whatever is required of me to lose weight.
   Definitely No — Definitely Yes
   1 2 3 4 5 6 7

2. If this program fails to help me lose weight, I will give up trying.
   Definitely No — Definitely Yes
   1 2 3 4 5 6 7

3. I try most new diets I hear about.
   Definitely No — Definitely Yes
   1 2 3 4 5 6 7

4. If I am thinner I will be more popular with other women.
   Definitely No — Definitely Yes
   1 2 3 4 5 6 7

5. If I am thinner I will be more popular with other men.
   Definitely No — Definitely Yes
   1 2 3 4 5 6 7

6. My mother is (was) overweight.
   Definitely No — Definitely Yes
   1 2 3 4 5 6 7

7. I was overweight when I was a child.
   Definitely No — Definitely Yes
   1 2 3 4 5 6 7

8. I enjoy good food.
   Definitely No — Definitely Yes
   1 2 3 4 5 6 7

9. I am willing to begin/maintain an exercise program for the rest of my life.
   Definitely No — Definitely Yes
   1 2 3 4 5 6 7

10. I eat between meals.
    Definitely No — Definitely Yes
    1 2 3 4 5 6 7

APPENDIX I

Handout of Literature Review

The following is a summary of research in the literature of obesity that pertains to differences between normal-weight people and overweight people, and describes techniques that have been successful for effective weight loss. Unfortunately, many people who are overweight may not be able to ever achieve desirable weight--at least until new techniques and weight-loss methods are discovered. Generally, weight-loss studies, which are usually conducted by clinical psychologists who specialize in obesity research, show modest success. It may be helpful to first explain what is known about the differences between normal-weight and overweight people.

Many overweight people are binge eaters, that is, they frequently eat several thousand calories at one sitting or within an hour or two. When people binge, they eat high-calorie foods, usually foods that can be consumed quickly. Some researchers have thought there might be an "obese eating style." A prominent researcher in the field, Michael J. Mahoney, studied men and women while they were eating and found that both overweight and normal-weight people eat about the same number of bites per minute and eat about the same length of time. Mahoney was watching people eating in a restaurant and they didn't know they were being watched. On the other hand, in a famous experiment by Stanley Schachter, people were watched eating in Chinese restaurants. Schachter speculated that overweight Caucasians would not use chopsticks because most Caucasians can consume more food more quickly with western silverware. He found that no very obese people used chopsticks, but a large number of normal-weight Caucasians ate with chopsticks.

Japanese sumo wrestlers eat about 5000-55[illegible] calories a day. Included in this diet is almost 100 grams of fat and almost 40[illegible] [illegible]ms of protein, with the remainder of the nutrients from carbohydrates. The typical Japanese diet consists of about 2200-2300 calories a day. Some researchers speculate that as American-style fast food invades Asian countries, Asian people will have the same weight problems as Americans. One researcher claims that obesity is rare in populations that consume high-fiber diets and obesity is quite common in populations that eat low-fiber diets.

One study monitored food intake of female ballet dancers and found that their average daily consumption is about 1350 calories. It has always been assumed that many ballet dancers and professional models suffer from anorexia. The ballet dancers eat less than men in another famous study who deliberately went on a semistarvation diet consisting of 1570 calories. These men were emaciated and miserable. These data suggest that diets containing only 1000-1200 calories a day are asking people to starve. The diets may be doomed to failure because they contain too few calories.

People who are athletic are seldom overweight. Middle-aged people who are regular tennis players can have about the same amount of body fat as men and women in college who do not play sports. One famous nutritionist, Jean Mayer, studied workers in a jute mill in India and found that the more sedentary workers were much heavier than the men engaged in hard labor, who were typically normal- or underweight. Mayer and others have also studied American girls and boys who were either obese or normal-weight. These studies indicate that obese and nonobese children eat about the same number of calories; the difference between the two groups is in the amount of exercise. In one study, obese girls spent about 4 hours a week in active sports, while the nonobese girls spent about 11 hours a week in active sports.

Kelly Brownell and his colleagues at the University of Pennsylvania studied more than 21,000 people at a major urban center in which there were both stairs and escalators. Six times as many nonobese people used the stairs as obese people. Whether overweight or not, significantly more younger people used stairs; older people are not as active, yet for cardiovascular reasons, it is imperative that older people exercise.

Overweight people sleep and sit more. One study showed that many obese people spend only about 6 hours a day standing and performing activities that require one to be out of bed or out of a chair. In other words, some overweight people may as well spend 18 hours a day in bed. A primary predictor of overweight in children is the number of hours they spend watching television. There are several possible reasons for this: the children are sitting or lying and not being active; they may be snacking (the more television children watch, the more they are likely to snack); and children who watch a lot of television are more likely to eat the high-calorie snacks advertised on television.

Women with more education are less likely to be overweight. People are more likely to gain weight in the late fall and winter months when the weather is bad and people stay indoors. During these times, clothes are bulky and people can cover up their bodies while eating with more abandon.

People who are overweight almost consistently fail to eat breakfast. Eating increases as the day passes, with much eating often done at night. Laboratory rats are often studied in obesity research because it is easy to manipulate their diets in ways one could not ethically control humans. The laboratory rat is a nibbler and generally eats very small amounts of food throughout its waking cycle. When the rat's food is controlled so that it must consume its ration in one or two meals, without increasing the amount consumed, it gains weight and fat. Further, these overweight rats may also decrease physical activity. It has been concluded that an infrequent meal pattern may be associated with a tendency toward obesity. One study looked at weights of children in three different boarding schools. The interesting difference in the diets between the schools was that one school was on a 3-meal-per-day plan, and the other two schools were on a 5- or 7-meal-per-day plan. The students eating 3 meals per day were fatter, on average, than the students in the other schools. In another study, young men and women were fed an extra 1400 kcal a day in either two meals or 14 small daily meals. Subjects in the first group gained weight; subjects in the second group did not gain weight even though they were consuming an excessive number of calories.

Another, perhaps amusing, factor indicating that overweight people consume more food is that they are more likely to have overweight pets. It has been found that rats, mice and dogs become obese when they are given diets that are high in fat. Calories are very dense in high-fat food because one gram of fat contains 7 calories, while a gram of sugar has only 4 calories. Heavier people may be much more attracted to very palatable diets. Van Itallie and his colleagues gave volunteers in a metabolic ward all their food by means of a bland liquid which was provided on demand by an automatically monitored food-dispensing device. Most obese subjects rarely ate more than 25% of the calories needed to maintain their weight and they lost weight rapidly. The normal-weight people took sufficient amounts of the drink to maintain their weight. This study indicates that overweight people will lose weight if good-tasting food is not available.

Not only do high-fat diets lead to obesity, diets that are varied cause people to overeat. When rats are given what is called a "supermarket" diet that includes cookies, salami, cheese, peanut butter, etc., they eat more and bigger meals, and they gain weight. One difference between the overweight and other people is that the overweight don't compensate for changes in caloric concentration. If an obese person is given a fattening drink in the laboratory, he or she will eat as much of another food as if the drink had been low in calories. In fact, some research has shown that if an overweight person is told that the food just consumed is high in calories, the person will eat more of another food than if the person is told that the food just consumed is low in calories -- regardless of whether or not the first food really was high in calories.

The question of whether obese people eat more food than normal-weight people has not been answered; indeed, there is much dispute over this issue. Some researchers say the obese eat even *less* food than others; some researchers say the obese eat more food. Most studies have used food diaries or recall measures to determine what people are eating. It is possible that the overweight are simply not remembering accurately. This does not mean that they are dishonest; it means that they perceive amounts of food in ways that are inaccurate. It is also possible that when the overweight are eating in public, they eat like normal-weight people. Most of their overeating may be done when they are assured of not being observed.

We can conclude with a fair amount of certainty that the overweight are less active than normal-weight people. This has been shown in numerous studies. The degree of difference, however, remains equivocal. I recently had 40 female college students wear an activity device for six days and found a significant, but modest, negative correlation between activity and amount of body fat. It would seem that there are several factors leading to overweight, exercise being only one factor. The other contributing factors are likely to be metabolism and amount of food consumed.

Given that one is overweight, what can be done to take off the pounds and lose the fat? First, it should be noted, that people don't lose weight on fad diets or diets that are unbalanced in nutrients. These diets can be dangerous, are difficult to stick to, and the dieter usually gives up after a very few days. As well he or she should.

The most successful diet for the largest number of people, to date, is a diet that is not within the reach of most dieters. This diet is the liquid very-low-calorie diet that is supervised usually by hospitals on an out-patient basis. The diets are very expensive, although they are famous because a few celebrities have lost large amounts of weight on them. When these diets are coupled with behavior modification techniques, weight-loss maintenance has been fairly good.

Although the basic low-calorie diet coupled with exercise has failed for so many dieters, when people lose weight successfully and keep off the lost weight, this is probably the diet these "winners" have used. These diets are sensible and sound. They do not demand the dieter enter a state of starvation in order to lose weight; they require that the dieter cut down about 500 calories a day. This way, one can lose about a pound a week. This doesn't seem to be much; but a steady pound per week is better than any other way and it is the only way for the lost weight to stay off.

It has been found that people whose weight "yo-yo's" up and down over a period of years have more and more difficulty even losing weight as years go by, let alone keeping off the lost weight. This fact has been demonstrated in people and in laboratory rats who have been cycled with high-fat diets followed by low-calorie diets. Each time the rat gains weight, it takes longer for the rat to attain normal weight even though the reducing diet is always the same. Research shows that the most important factor in dieting is to find a way, not only to take off the weight, but to keep off the lost weight indefinitely.

In order to do this, the dieter must incorporate exercise into his or her life FOREVER. If the dieter is unwilling to do this, he or she is almost certainly doomed to regain the lost weight. It is important to think of things to do that are pleasurable and can be incorporated into one's daily routine. It is possible to explore new activities, say tennis or swimming. There are alternatives to aerobics tapes and sit-ups.

It is suggested that the dieter cut down on fats. Fats are almost twice as fattening as any other food. A teaspoon of butter has twice as many calories as a teaspoon of sugar. Sugar consumption is lower in overweight people than in normal-weight people. In fact, sugar has appetite suppressing qualities and it should not be avoided in small amounts. Diet food has not been of much use to any dieter. The dieter should make sure to incorporate good-sized amounts of high-fiber foods in the diet. One researcher gave overweight male dieters 12 slices of bread a day and they all lost significant amounts of weight. When the men were seen several months later, those who were still eating large amounts of bread had kept off the weight; those who stopped eating the bread had regained their weight. Alcohol can provide as much as 25% of one's daily calorie intake. Cutting out alcohol alone can help some people lose substantial amounts of weight.

I hope you are able to find some helpful advice from this research summary. If you have any suggestions or helpful ideas that have not been mentioned here, please let me know. It is important to update the knowledge in this area. Good luck to you, and successful dieting and maintenance!

APPENDIX J

Pearson Product-Moment Correlations -- Experiment 2

23-Jul-90 SPSS-X RELEASE 3.1 FOR VAX/VMS
09:05:52 SPSS-X 3.12 VAX/VMS UNH on UNHH:: VMS V5.3

- - - - - - - - - - - - - - - P E A R S O N C O R R E L A T I O N C O E F F I C I E N T S - - - - - - - - - - - - - -

	PREBMI	POSTBMI	PRESKIN	CIRCUM	PAFF	CHANGE	NETWT	WTLOST	BMILOST	PREWT	POSTWT
PREBMI	1.0000 (20) P= .	.9895 (20) P= .000	.7274 (20) P= .000	-.4602 (20) P= .021	-.2212 (20) P= .174	.4181 (19) P= .037	.2639 (19) P= .137	-.0171 (20) P= .472	-.0318 (19) P= .449	.8528 (20) P= .000	.8223 (20) P= .000
POSTBMI	.9895 (20) P= .000	1.0000 (20) P= .	.7131 (20) P= .000	-.3778 (20) P= .050	-.2082 (20) P= .189	.4432 (19) P= .029	.3133 (19) P= .096	.1235 (20) P= .302	.1178 (19) P= .316	.8201 (20) P= .000	.8063 (20) P= .000
PRESKIN	.7274 (20) P= .000	.7131 (20) P= .000	1.0000 (20) P= .	-.4771 (20) P= .017	-.2845 (20) P= .112	.1980 (19) P= .208	.1707 (19) P= .242	-.1162 (20) P= .313	-.0680 (19) P= .391	.7914 (20) P= .000	.7346 (20) P= .000
CIRCUM	-.4602 (20) P= .021	-.3778 (20) P= .050	-.4771 (20) P= .017	1.0000 (20) P= .	-.0521 (20) P= .414	.2185 (19) P= .184	.0366 (19) P= .441	.5661 (20) P= .005	.5559 (19) P= .007	-.4957 (20) P= .013	-.4293 (20) P= .029
PAFF	-.2212 (20) P= .174	-.2082 (20) P= .189	-.2845 (20) P= .112	-.0521 (20) P= .414	1.0000 (20) P= .	-.2035 (19) P= .202	-.0041 (19) P= .493	.0871 (20) P= .357	.0704 (19) P= .387	-.3603 (20) P= .059	-.3705 (20) P= .054
CHANGE	.4181 (19) P= .037	.4432 (19) P= .029	.1980 (19) P= .208	.2185 (19) P= .184	-.2035 (19) P= .202	1.0000 (19) P= .	.4730 (19) P= .020	.2028 (19) P= .202	.2708 (18) P= .139	.3109 (19) P= .098	.2886 (19) P= .115
NETWT	.2639 (19) P= .137	.3133 (19) P= .096	.1707 (19) P= .242	.0366 (19) P= .441	-.0041 (19) P= .493	.4730 (19) P= .020	1.0000 (19) P= .	.2858 (19) P= .118	.3741 (18) P= .063	.2070 (19) P= .198	.2624 (19) P= .139
WTLOST	-.0171 (20) P= .472	.1235 (20) P= .302	-.1162 (20) P= .313	.5661 (20) P= .005	.0871 (20) P= .357	.2028 (19) P= .202	.2858 (19) P= .118	1.0000 (20) P= .	.9741 (19) P= .000	-.1691 (20) P= .238	-.0627 (20) P= .396
BMILOST	-.0318 (19) P= .449	.1178 (19) P= .316	-.0680 (19) P= .391	.5559 (19) P= .007	.0704 (19) P= .387	.2708 (18) P= .139	.3741 (18) P= .063	.9741 (19) P= .000	1.0000 (19) P= .	-.1948 (19) P= .212	-.0656 (19) P= .395
PREWT	.8528 (20) P= .000	.8201 (20) P= .000	.7914 (20) P= .000	-.4957 (20) P= .013	-.3603 (20) P= .059	.3109 (19) P= .098	.2070 (19) P= .198	-.1691 (20) P= .238	-.1948 (19) P= .212	1.0000 (20) P= .	.9729 (20) P= .000
POSTWT	.8223 (20) P= .000	.8063 (20) P= .000	.7346 (20) P= .000	-.4293 (20) P= .029	-.3705 (20) P= .054	.2886 (19) P= .115	.2624 (19) P= .139	-.0627 (20) P= .396	-.0656 (19) P= .395	.9729 (20) P= .000	1.0000 (20) P= .

(COEFFICIENT / (CASES) / 1-TAILED SIG) " . " IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED

APPENDIX K

Pearson Product-Moment Correlations with Skewed and Kurtotic Variables Recoded - Experiment 2

SPSS-X RELEASE 3.1 FOR VAX/VMS
SPSS-X 3.12 VAX/VMS UNH on UNHH:: VMS V5.3

- - - - - - - - - - P E A R S O N   C O R R E L A T I O N   C O E F F I C I E N T S - - - - - - - - - - - - - - -

	PREBMI	POSTBMI	PRESKIN	CIRCUM	PAFF	CHANGE	NETWT	WTLOST	BMILOST	PREWT	POSTWT
PREBMI	1.0000 (20) P= .	.9895 (20) P= .000	.7274 (20) P= .000	-.4602 (20) P= .021	-.2212 (20) P= .174	.4181 (19) P= .037	.2639 (19) P= .137	-.0171 (20) P= .472	-.0318 (19) P= .449	.8528 (20) P= .000	.8223 (20) P= .000
POSTBMI	.9895 (20) P= .000	1.0000 (20) P= .	.7131 (20) P= .000	-.3778 (20) P= .050	-.2082 (20) P= .189	.4432 (19) P= .029	.3133 (19) P= .096	.1235 (20) P= .302	.1178 (19) P= .316	.8201 (20) P= .000	.8063 (20) P= .000
PRESKIN	.7274 (20) P= .000	.7131 (20) P= .000	1.0000 (20) P= .	-.4771 (20) P= .017	-.2845 (20) P= .112	.1980 (19) P= .208	.1707 (19) P= .242	-.1162 (20) P= .313	-.0680 (19) P= .391	.7914 (20) P= .000	.7346 (20) P= .000
CIRCUM	-.4602 (20) P= .021	-.3778 (20) P= .050	-.4771 (20) P= .017	1.0000 (20) P= .	-.0521 (20) P= .414	.2185 (19) P= .184	.0366 (19) P= .441	.5661 (20) P= .005	.5559 (19) P= .007	-.4957 (20) P= .013	-.4293 (20) P= .029
PAFF	-.2212 (20) P= .174	-.2082 (20) P= .189	-.2845 (20) P= .112	-.0521 (20) P= .414	1.0000 (20) P= .	-.2035 (19) P= .202	-.0041 (19) P= .493	.0871 (20) P= .357	.0704 (19) P= .387	-.3603 (20) P= .059	-.3705 (20) P= .054
CHANGE	.4181 (19) P= .037	.4432 (19) P= .029	.1980 (19) P= .208	.2185 (19) P= .184	-.2035 (19) P= .202	1.0000 (19) P= .	.4730 (19) P= .020	.2028 (19) P= .202	.2708 (18) P= .139	.3109 (19) P= .098	.2886 (19) P= .115
NETWT	.2639 (19) P= .137	.3133 (19) P= .096	.1707 (19) P= .242	.0366 (19) P= .441	-.0041 (19) P= .493	.4730 (19) P= .020	1.0000 (19) P= .	.2858 (19) P= .118	.3741 (18) P= .063	.2070 (19) P= .198	.2624 (19) P= .139
WTLOST	-.0171 (20) P= .472	.1235 (20) P= .302	-.1162 (20) P= .313	.5661 (20) P= .005	.0871 (20) P= .357	.2028 (19) P= .202	.2858 (19) P= .118	1.0000 (20) P= .	.9741 (19) P= .000	-.1691 (20) P= .238	-.0627 (20) P= .396
BMILOST	-.0318 (19) P= .449	.1178 (19) P= .316	-.0680 (19) P= .391	.5559 (19) P= .007	.0704 (19) P= .387	.2708 (18) P= .139	.3741 (18) P= .063	.9741 (19) P= .000	1.0000 (19) P= .	-.1948 (19) P= .212	-.0656 (19) P= .395
PREWT	.8528 (20) P= .000	.8201 (20) P= .000	.7914 (20) P= .000	-.4957 (20) P= .013	-.3603 (20) P= .059	.3109 (19) P= .098	.2070 (19) P= .198	-.1691 (20) P= .238	-.1948 (19) P= .212	1.0000 (20) P= .	.9729 (20) P= .000
POSTWT	.8223 (20) P= .000	.8063 (20) P= .000	.7346 (20) P= .000	-.4293 (20) P= .029	-.3705 (20) P= .054	.2886 (19) P= .115	.2624 (19) P= .139	-.0627 (20) P= .396	-.0656 (19) P= .395	.9729 (20) P= .000	1.0000 (20) P= .

(COEFFICIENT / (CASES) / 1-TAILED SIG)   " . " IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED