

# The Effects of Starvation on Behavior: Implications for Dieting and Eating Disorders

by David M. Garner, PhD

One of the most important advances in the understanding of eating disorders is the recognition that severe and prolonged dietary restriction can lead to serious physical and psychological complications.<sup>1</sup> Many of the symptoms once thought to be primary features of anorexia nervosa are actually symptoms of starvation. Given what we know about the biology of weight regulation, what is the impact of weight suppression on the individual? This question is particularly relevant for health professionals who treat eating disorders, but is also important in obesity treatment, for dieters, and for others who have lost significant amounts of body weight.

Perhaps the most powerful illustration of the effects of restrictive dieting and weight loss on behavior is an experimental study conducted over 50 years ago and published in 1950

by Ancel Keys and his colleagues at the University of Minnesota.<sup>2</sup> The experiment involved carefully studying 36

young, healthy, psychologically normal men while restricting their caloric intake for 6 months. More than 100 men volunteered for the study as an alternative to military service; the 36 selected had the highest levels of physical and psychological health, as well as the most commitment to the objectives of the experiment. What makes the "starvation study," as it is commonly known, so important is that many of the experiences observed in the volunteers are the same as those experienced by patients with eating disorders as well as some people who have undergone weight loss programs.

During the first 3 months of the semistarvation experiment, the volunteers ate normally while their behavior, personality, and eating patterns were studied in detail. During the next 6 months, the men were restricted to approximately half of their former food intake and lost, on average, approximately 25 percent of their former weight. Although this was described as a study of "semistarvation," it is important to keep in mind that cutting the men's rations to half of their former intake (to an average of 1,570 calories) is precisely the level of caloric deficit used to define "conservative" treatments for obesity.<sup>3</sup> The 6 months of weight loss were followed by 3 months of rehabilitation, during which the men were gradually refed. A subgroup was followed for almost 9 months after the refeeding began. Most of the results were reported for only 32 men,

because four men were withdrawn either during or at the end of the semistarvation phase. Although the individual responses to weight loss varied considerably, the men experienced dramatic physical, psychological, and social changes. In most cases, these changes persisted during the rehabilitation or renourishment phase.

## Attitudes and behavior related to food and eating

One of the most striking changes that occurred in the volunteers was a dramatic increase in food preoccupation. The men found concentration on their usual activities increasingly difficult, because they became plagued by incessant thoughts of food and eating. During the semistarvation phase of the experiment, food became a principal topic of conversation, reading, and day-

dreams. Rating scales revealed that the men experienced increase in thoughts about food, as well as corresponding decreases in interest

in sex and activity during semistarvation. The actual words used in the original report are particularly revealing and the following quotations followed by page numbers in parentheses are from Keys et al. with permission from the University of Minnesota Press.

"As starvation progressed, the number of men who toyed with their food increased. They made what under normal conditions would be weird and distasteful concoctions, (p. 832)... Those who ate in the common dining room smuggled out bits of food and consumed them on their bunks in a long-drawn-out ritual, (p. 833)... Toward the end of starvation some of the men would dawdle for almost 2 hours after a meal which previously they would have consumed in a matter of minutes, (p. 833)... Cookbooks, menus, and information bulletins on food production became intensely interesting to many of the men who previously had little or no interest in dietetics or agriculture, (p. 833)... [The volunteers] often reported that they got a vivid vicarious pleasure from watching other persons eat or from just smelling food (p. 834)..."

In addition to reading cookbooks and collecting recipes, some of the men even began collecting coffee pots, hot plates, and other kitchen utensils. According to the original report, hoarding even extended to non-food-related items such as "old books, unnecessary second-hand clothes, knick knacks, and other 'junk.' Often

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after making such purchases, which could be afforded only with sacrifice, the men would be puzzled as to why they had bought such more or less useless articles" (p. 837). One man even began rummaging through garbage cans. This general tendency to hoard has been observed in starved anorexic patients and even in rats deprived of food.<sup>4,5</sup> Despite little interest in culinary matters prior to the experiment, almost 40 percent of the men mentioned cooking as one of their postexperiment plans. For some, the fascination was so great *that they actually changed occupations after the experiment*; three became chefs!

The Minnesota subjects often were caught between conflicting desires to gulp their food down ravenously and consume it slowly so that the taste and odor of each morsel would be fully appreciated.

They did much planning as to how they would handle their day's allotment of food (p. 833). The men demanded that their food be served hot, and they made unusual concoctions by mixing foods together, as noted above. There also was a marked increase in the use of salt and spices. The consumption of coffee and tea increased so dramatically that the men had to be limited to nine cups per day; similarly, gum chewing became excessive and had to be limited after it was discovered that one man was chewing as many as 40 packages of gum a day and "developed a sore mouth from such continuous exercise" (p. 835).

During the 12-week refeeding phase of the experiment, most of the abnormal attitudes and behaviors related to food persisted.

### Binge eating

During the restrictive dieting phase of the experiment, all of the volunteers reported increased hunger. Some appeared able to tolerate the experience fairly well, but for others it created intense concern and led to a complete breakdown in control. Several men were unable to adhere to their diets and reported episodes of binge eating followed by self-reproach. During the eighth week of starvation, one volunteer flagrantly broke the dietary rules, eating several sundaes and malted milks; he even stole some penny candies. He promptly confessed the whole episode, [and] became self-deprecatory (p. 884). While working in a grocery store, another man suffered a complete loss of will power and ate several cookies, a sack of popcorn, and two overripe bananas before he could regain control of himself. He immediately suffered a severe emotional upset, with nausea, and upon returning to the laboratory he vomited... He was self-deprecatory, expressing disgust and self-criticism (p. 887).

One man was released from the experiment at the end of the semistarvation period because of suspicions that he was unable to adhere to the diet. He experienced serious difficulties when confronted with unlimited access to food: "He repeatedly went through the

cycle of eating tremendous quantities of food, becoming sick, and then starting all over again" (p. 890). During the refeeding phase of the experiment, many of the men lost control of their appetites and "ate more or less continuously" (p. 843). Even after 12 weeks of refeeding, the men frequently complained of increased hunger immediately following a large meal.

"[One of the volunteers] ate immense meals (a daily estimate of 5,000 to 6,000 calories) and yet started snacking an hour after he finished a meal. [Another] ate as much as he could hold during the three regular meals and ate snacks in the morning, afternoon, and evening, (p. 846)... Several men had spells of nausea and vomiting. One man required aspiration and hospitalization for several days, (p. 843)..."

During the weekends in particular, some of the men found it difficult to stop eating. Their daily intake commonly ranged between 8,000 and 10,000 calories, and their eating patterns were described as follows:

*Subject No. 20 stuffs himself until he is bursting at the seams, to the point of being nearly sick and still feels hungry; No. 120 reported that he had to discipline himself to keep from eating so much as to become ill; No. 1 ate until he was uncomfortably full; and subject No. 30 had so little control over the mechanics of "piling it in" that he simply had to stay away from food because he could not find a point of satiation even when he was "full to the gills..." "I ate practically all weekend," reported subject No. 26... Subject No. 26 would just as soon have eaten six meals instead of three. (p. 847)*

After about 5 months of refeeding, the majority of the men reported some normalization of their eating patterns, but for some the extreme overconsumption persisted "No. 108 would eat and eat until he could hardly swallow any more and then he felt like eating half an hour later" (p. 847). More than 8 months after renourishment began, most men had returned to normal eating patterns; however, a few were still eating abnormal amounts. "No. 9 ate about 25 percent more than his prestarvation amount; once he started to reduce but got so hungry he could not stand it" (p. 847).

Factors distinguishing men who rapidly normalized their eating from those who continued to eat prodigious amounts were not identified. Nevertheless, the main findings here are as follows: *Serious binge eating developed in a subgroup of men, and this tendency persisted in some cases for months after free access to food was reintroduced; however, the majority of men reported gradually returning to eating normal amounts of food after about 5 months of refeeding.* Thus, the fact that binge eating was experimentally produced in some of these normal young men should temper speculations about primary psychological disturbances as the cause of binge eating in patients with eating disorders.

These findings are supported by a large body of research indicating that habitual dieters display marked overcompensation in eating behavior that is similar to the binge eating observed in eating disorders.<sup>6-8</sup> Polivy et al. compared a group of former World War II prisoners of war and noninterned veterans and found that the former prisoners who had lost an average of 10.5 kg while prisoners of war, reported a significantly higher frequency of binge eating than noninterned veterans according to a self-report questionnaire sent by mail.

### Emotional and personality changes

The experimental procedures involved selecting volunteers who were the most physically and psychologically robust. "The psychobiologic 'stamina' of the subjects was unquestionably superior to that likely to be found in any random or more generally representative sample of the population" (pp. 915-916).

Although the subjects were psychologically healthy prior to the experiment, most experienced significant emotional deterioration as a result of semistarvation. Most subjects experienced periods during which their emotional distress was quite severe; almost 20 percent had extreme emotional deterioration that markedly interfered with their functioning. Depression became more severe during the course of the experiment. Mood swings were extreme for some of the volunteers:

*[One subject] experienced a number of periods in which his spirits were definitely high... These elated periods alternated with times in which he suffered "a deep dark depression." (p. 903)*

Irritability and frequent outbursts of anger were common, although the men had fairly tolerant dispositions prior to starvation. For most subjects, anxiety became more evident. As the experiment progressed, many of the formerly even-tempered men began biting their nails or smoking because they felt nervous. Apathy also became common, and some men who had been moderately fastidious neglected various aspects of personal hygiene. During semistarvation, two subjects developed disturbances of psychotic proportions. During the refeeding period, emotional disturbance did not vanish immediately but persisted for several weeks, with some men actually becoming more depressed, irritable, argumentative, and negativistic than they had been during semistarvation. After 2 weeks of refeeding, one man reported his extreme reaction in his diary:

*I have been more depressed than ever in my life... I thought that there was only one thing that would pull me out of the doldrums, that is release from C.P.S. [the experiment] I decided to get rid of some fingers. Ten days ago, I jacked up my car and let the car fall on these fingers... It was premeditated. (pp. 894-895)*

Several days later, this man actually did *chop off three fingers of one hand* in response to the stress.

Standardized personality testing with the Minnesota Multiphasic Personality Inventory (MMPI) revealed that semistarvation resulted in significant increases on the Depression, Hysteria, and Hypochondriasis scales. The MMPI profiles for a small minority of subjects confirmed the clinical impression of incredible deterioration as a result of semistarvation. One man scored well within normal limits at initial testing, but after 10 weeks of semistarvation and a weight loss of only about 4.5 kg (10 pounds, or approximately 7 percent of his original body weight), gross personality disturbances were evident on the MMPI.

### Social and sexual changes

The extraordinary impact of semistarvation was reflected in the social changes experienced by most of the volunteers. Although originally quite gregarious, the men became progressively more withdrawn and isolated. Humor and the sense of comradeship diminished amidst growing feelings of social inadequacy. The volunteers' social contacts with women also declined sharply during semistarvation. Those who continued to see women socially found that the relationships became strained. These changes are illustrated in the account from one man's diary:

*I am one of about three or four who still go out with girls. I fell in love with a girl during the control period but I see her only occasionally now. It's almost too much trouble to see her even when she visits me in the lab. It requires effort to hold her hand. Entertainment must be tame. If we see a show, the most interesting part of it is contained in scenes where people are eating. (p. 853)*

Sexual interests were likewise drastically reduced. Masturbation, sexual fantasies, and sexual impulses either ceased or became much less common. One subject graphically stated that he had "no more sexual feeling than a sick oyster." (Even this peculiar metaphor made reference to food.) Keys et al. observed that "many of the men welcomed the freedom from sexual tensions and frustrations normally present in young adult men" (p. 840). The fact that starvation perceptibly altered sexual urges and associated conflicts is of particular interest, since it has been hypothesized that this process is the driving force behind the dieting of many anorexia nervosa patients. According to Crisp, anorexia nervosa is an adaptive disorder in the sense that it curtails sexual concerns for which the adolescent feels unprepared.<sup>10</sup> During rehabilitation, sexual interest was slow to return. Even after 3 months, the men judged themselves to be far from normal in this area. However, after 8 months of renourishment, virtually all of the men had recovered their interest in sex.

## Cognitive and physical changes

The volunteers reported impaired concentration, alertness, comprehension, and judgment during semistarvation; however, formal intellectual testing revealed no signs of diminished intellectual abilities. As the 6 months of semistarvation progressed, the volunteers exhibited many physical changes, including gastrointestinal discomfort; decreased need for sleep; dizziness; headaches; hypersensitivity to noise and light; reduced strength; poor motor control; edema (an excess of fluid causing swelling); hair loss; decreased tolerance for cold temperatures (cold hands and feet); visual disturbances (i.e., inability to focus, eye aches, "spots" in the visual fields); auditory disturbances (i.e., ringing noise in the ears); and paresthesias (i.e., abnormal tingling or prickling sensations, especially in the hands or feet).

Various changes reflected an overall slowing of the body's physiologic processes. There were decreases in body temperature, heart rate, and respiration, as well as in basal metabolic rate (BMR), the amount of energy (in calories) that the body requires at rest (i.e., no physical activity) to carry out normal physiologic processes. It accounts for about two thirds of the body's total energy needs, with the remainder being used during physical activity. At the end of semistarvation, the men's BMRs had dropped by about 40 percent from normal levels. This drop, as well as other physical changes, reflect the body's extraordinary ability to adapt to low caloric intake by reducing its need for energy. More recent research has shown that metabolic rate is markedly reduced even among dieters who do not have a history of dramatic weight loss.<sup>11</sup> During refeeding, Keys et al. found that metabolism speeded up, with those consuming the greatest number of calories experiencing the great rise in BMR. The group of volunteers who received a relatively small increment in calories during refeeding (400 calories more than during semistarvation) had no rise in BMR for the first 3 weeks. Consuming larger amounts of food caused a sharp increase in the energy burned through metabolic processes.

## Significance of the "Starvation Study"

As is readily apparent from the preceding description of the Minnesota experiment, many of the symptoms that might have been thought to be specific to anorexia nervosa and bulimia nervosa are actually the result of starvation.<sup>12</sup> These are not limited to food and weight, but extend to virtually all areas of psychological and social functioning. Since many of the symptoms postulated to cause these disorders may actually result from undernutrition, it is absolutely essential that weight be returned to "normal" levels so that psychological functioning can be accurately assessed.

The profound effects of starvation also illustrate the tremendous adaptive capacity of the human body and

the intense biologic pressure on the organism to maintain a relatively consistent body weight. This makes complete evolutionary sense. Over hundreds of thousands of years of human evolution, a major threat to the survival of the organism was starvation. If weight had not been carefully modulated and controlled internally, early humans most certainly would simply have died when food was scarce or when their interest was captured by countless other aspects of living. The "starvation study" by Keys et al. illustrates how the human being becomes more oriented toward food when starved and how other pursuits important to the survival of the species (e.g., social and sexual functioning) become subordinate to the primary drive toward food.

Some researchers have indicated publicly that this study could not be conducted today because of the stringent ethical guidelines for research using human subjects. However, rarely have ethical concerns been raised regarding the use of very low calorie diets that involve a level of calorie restriction that is approximately one half of that used in the "starvation study." In light of the profound changes observed in the "starvation study," it would seem mandatory to warn participants of these potentially untoward effects as well as to carefully study the psychological and physical impact of these programs.

Providing patients with eating disorders with the above account of the semistarvation study can be very useful in giving them an explanation for many of the emotional, cognitive, and behavioral symptoms that they experience. Recommendations to use the findings of this study, as well as other educational materials,<sup>1</sup> are based on the assumption that patients with eating disorder often suffer from misconceptions about the factors that cause and then maintain symptoms. It is further assumed that patients may be less likely to persist in self-defeating symptoms if they are made truly aware of the scientific evidence regarding factors that perpetuate eating disorders.

One of the most notable implications of the Minnesota experiment is that it challenges the popular notion that body weight is easily altered if one simply exercises a bit of "willpower." It also demonstrates that the body is not simply "reprogrammed" at a lower set point once weight loss has been achieved. The volunteers' experimental diet was unsuccessful in overriding their bodies' strong propensity to defend a particular weight level. Again, it is important to emphasize that following the months of refeeding, the Minnesota volunteers did not skyrocket into obesity. On average, they gained back their original weight plus about 10 percent; then, over the next 6 months, their weight gradually declined. By the end of the follow up period, they were approaching their pre-experiment weight levels.

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## How to Measure Malnutrition

For simplicity, weight is often used as a measure of malnutrition. The United Nations Food and Agriculture Organization (FAO) recently adopted body weight as the standard to measure nutritional status and starvation worldwide. A body mass index of 18.5 is defined as the cutoff point for chronic energy deficiency in adults. Weights below this level are highly correlated with starvation, deficiencies of the immune system, illness, morbidity, and mortality, according to the 1995 FAO report *Body Mass Index: A measure of chronic energy deficiency in adults*. Thus, a BMI of 18.5 is regarded as the lower limit of healthy weight. (It is acknowledged that some healthy people may weigh less than this, particularly if they are tall and thin.) Far greater attention needs to be paid to adult underweight, as physical effectiveness and the ability to withstand illness and stress is severely compromised, says the report.

Protein-calorie malnutrition, especially in older persons, is usually based on such measures as weight, loss of weight, serum concentrations of proteins produced by the liver, anthropometric measurements, grip strength, energy, immunologic functions, low cholesterol, low albumin, nutritional risk index, and may also include dysphoria (sadness), eating problems, and shopping problems. Historic weight loss is known to be an excellent measure of nutritional depletion in persons who do not have a disease of water metabolism. Low albumin and cholesterol concentrations usually indicate both malnutrition and excessive cytokine production. The gold standard for the diagnosis of protein-energy malnutrition in older persons is the Mini Nutritional Assessment (MNA) initially developed at the University of Toulouse in France in collaboration with Nestle in Lausanne, Switzerland. Two other screening tests for older persons are the Nutrition Screening Initiative (DETERMINE) and SCALES.

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Height (ins.)	Body Mass Index		
	17	18	19
	Weight (lbs.)	Weight (lbs.)	Weight (lbs.)
60	85	90	95
62	90	100	105
64	100	105	110
66	105	115	120
68	110	120	125
70	120	125	130
72	125	135	140

Adapted from Guidelines for Adolescent Preventive Services, AMA 1995.