



Sylvia R. Karasu M.D.
The Gravity of Weight

Crossing the Thin Line to Starvation: Caloric Restriction

Beneficial or detrimental? The "dietary landscape" of caloric intake.

Like 8

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The Hunger March at the forgotten conflict meeting in Copenhagen, October 2003. Source: <http://www.aidoh.dk>. (Author: Jens Galschiot)

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In the creepy dystopian future of Max Ehrlich's *The Edict* (1971), the population has burgeoned out of control because there is no longer any cancer or cardiovascular disease. The average age in its "Senior City" was 100; many lived until 125 and some as long as 150 years because older people were "a patchwork of other people's parts." (p. 74) There was, however, not much food—only algae and plankton—and the average daily calorie allotment, scientifically calculated based on the ratio of births to deaths, was 652 calories. As a result, 90 percent of all deaths were due to "simple malnutrition."

For entertainment, the population went to titillating films called "Foodies," where they would watch vintage footage of old time supermarkets filled with fresh vegetables and fruits. The only part of the film this severely malnourished audience could not fathom was the diet section of the supermarket where there were shelves of low or no calorie items. But as the audience watched scenes of people eating real food like enormous pieces of roast beef or "a great slice

of chocolate cake" with "a sticky bouquet of chocolate frosting," they would salivate and let out a collective

moan, as if watching a pornographic movie, as their mouths "opened and closed in symbiotic union." (p. 133)



Christian Krohg (1852-1925): "Struggle for Existence," 1889.

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Throughout history, there have been many devastating famines, particularly in times of war and political conflict. During the Dutch famine of World War II, for example, the official rationing went from 1,800 calories a day in 1943 to 619 calories in the first quarter of 1945. (Keys et al, *Biology of Human Starvation*, Volume I, 1950, p. 25) It was even worse for the victims of the Lodz and Warsaw Ghettos (Weisz and Albury, *Israel Medical Association Journal*, 2013) and Nazi Concentration Camps: the official daily ration at Auschwitz was one liter of watery soup; 250 grams of bread; 20-25 grams of margarine or sausage or imitation honey. Explains Lucie Adelsberger, a Jewish physician imprisoned there, "These quantities became in time insufficient to support life, and the German camp doctors admitted that a prisoner could not hope to survive on them much longer than six months." (Adelsberger, *The Lancet*, 1946) In Belsen, technically a detention camp and not an organized extermination camp, where the daily caloric intake was under 800 calories a day, if

that, (Lipscomb, *The Lancet*, 1945) the average male survivor weighed 44 kilos (97 pounds) and the average female survivor weighed 35.3 kilos (77.8 pounds) at the time of the camp's liberation, with an average loss of almost 40 percent of body weight. (Mollison, *British Medical Journal*, 1946.)

Most people can tolerate a weight loss of about 5 to 10 percent "with relatively little functional disorganization" but humans do not survive weight losses that are greater than 35 to 40 percent. (Keys et al, 1950, p.18, Vol. I) With war-ravaged Europe in mind, Ancel Keys and his colleagues at the University of Minnesota designed an experiment with a group of 36 conscientious objectors to assess the effects of caloric restriction



Polish artist Grzegorz Stec, "Hunger." (2010). Source: from the artist, licensed under the Creative Commons Attribution-Share

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that mimicked the malnourished diet (e.g. mostly potatoes, turnips, dark bread) of Europeans. The brochure proclaimed, "Will You Starve That They Be Better Fed?" The investigators' results were published in a meticulous two-volume tome, *Biology of Human Starvation* (1950.) Beginning in 1945, these men went from about 3,200 calories a day to about 1,800 calories, but continuously titrated down so that the men were to lose about 25 percent of their body weight (and walk 22 miles a week) in semi-starvation conditions over six months prior to a three-month rehabilitation period. The men became completely preoccupied with food, as they developed depression, nervousness, social withdrawal, anemia, fatigue, apathy,

extreme weakness, irritability, neurological deficits, edema, loss of sexual interest, and inability to concentrate. Keys et al called the constellation of symptoms, a "semi-starvation neurosis." (p. 909, Volume II) Though the men found the experience grueling, when interviewed years later, they were proud to have participated. And unlike the conditions in Europe, said one participant, "We were starving under the best possible medical conditions. And most of all, we knew the exact day on which our torture would end." (Kalm and Semba, *Journal of Nutrition*, 2005.)



"Emaciated Horse with Rider," ca 1625, Attributed to India, Deccan, Bijapur. Credit line: Rogers Fund, 1944. (Currently not on view at the Metropolitan Museum of Art, NYC.)

Source: Metmuseum, Public Domain, scholarly use

Keys et al noted that there is an important difference between a prolonged period of inadequate caloric intake and total fasting: With under-nutrition, the feelings of hunger get worse over time, whereas with total abstinence, hunger sensations dissipate in a few days. (Keys et al, p. 29, Vol. I)

What happens, though, when calories are restricted but there is adequate nutrition? Since the 1930s, researchers have questioned the value of restricting caloric intake, while maintaining adequate protein, fat, and carbohydrates, to benefit health and even to extend life. Caloric intake depends on our age, level of activity, and

whether male or female. For example, adult men (before the age of 50) who are very active (e.g. walking

quickly for more than three miles a day for more than 40 minutes, as well as usual activities) require about 2,400 to 2,800 calories a day; very active adult women may require about 2,200 calories a day. As we age, we require fewer calories. (Health and Human Services, NIH) The Institute of Medicine suggests the following ranges: 10 to 35 percent calories from protein; 20 to 35 percent from fat; and 45 to 65 percent from carbohydrates. (Dwyer, Chapter 95e, *Harrison's Textbook of Medicine*, 19th Edition, online.)



"Singapore: The Cookhouse, Changi Gaol," British POWs prepare their main meal of rice, by Leslie Cole (1910-1976); Image released by the Imperial War Museum. Restricting caloric intake to starvation rations for prisoners is typical during war.

Source: Wikimedia Commons/Public Domain

For years, researchers have found that many species (e.g. fruit flies, rodents), though not all (and even depending on strain of rodent) have not only substantially lengthened their lifespans through caloric restriction while maintaining adequate nutrition, but have also decreased their incidence of cancers as well as metabolic and immunological abnormalities. (Sohal and Forster, *Free Radical Biology & Medicine*, 2014) In an attempt to extrapolate their findings to humans, researchers have undertaken several major, long-term studies in non-human primates (e.g. rhesus monkeys) to assess the effect of caloric restriction (CR) on longevity. The results have been inconsistent: a study from the University of Wisconsin found a significant positive effect of CR on lifespan while a study from the National

Institute on Aging did not find CR increased lifespan, though both groups found substantial health benefits. Allison and his colleagues, who conducted the statistical analysis for both studies, (Mattison et al, *Nature Communications*, 2017) explained the discrepancies in outcome: there were fundamental differences in each study's design and implementation. For example, there were different feeding schedules; different diet compositions including different amounts of protein and vastly different amounts of sugar in the diets; different age ranges for the initiation of the intervention of CR, and even different genetic strains of monkeys. Further, they acknowledged "the minimum degree of food restriction for maximum benefit has not been identified." And at a certain point, caloric restriction can go from being beneficial to being detrimental. (Roberts and Speakman, *Advances in Nutrition*, 2013)

Since non-human primates, though, share our "catalogue of pathologies" typical of our own aging, Allison and colleagues (Mattison et al, 2017) believe that there is a likely benefit of CR with adequate nutrition for lowering age-related



Austrian artist Egon Schiele, "Self-Portrait," 1911. Credit line: Bequest of Scofield Thayer, 1982. Currently not on view at the Metropolitan Museum of Art, NYC. Many artists, including Schiele, are known for drawing emaciated human figures. See those by Giacometti as well.

Source: Metmuseum/scholarly use/Public Domain

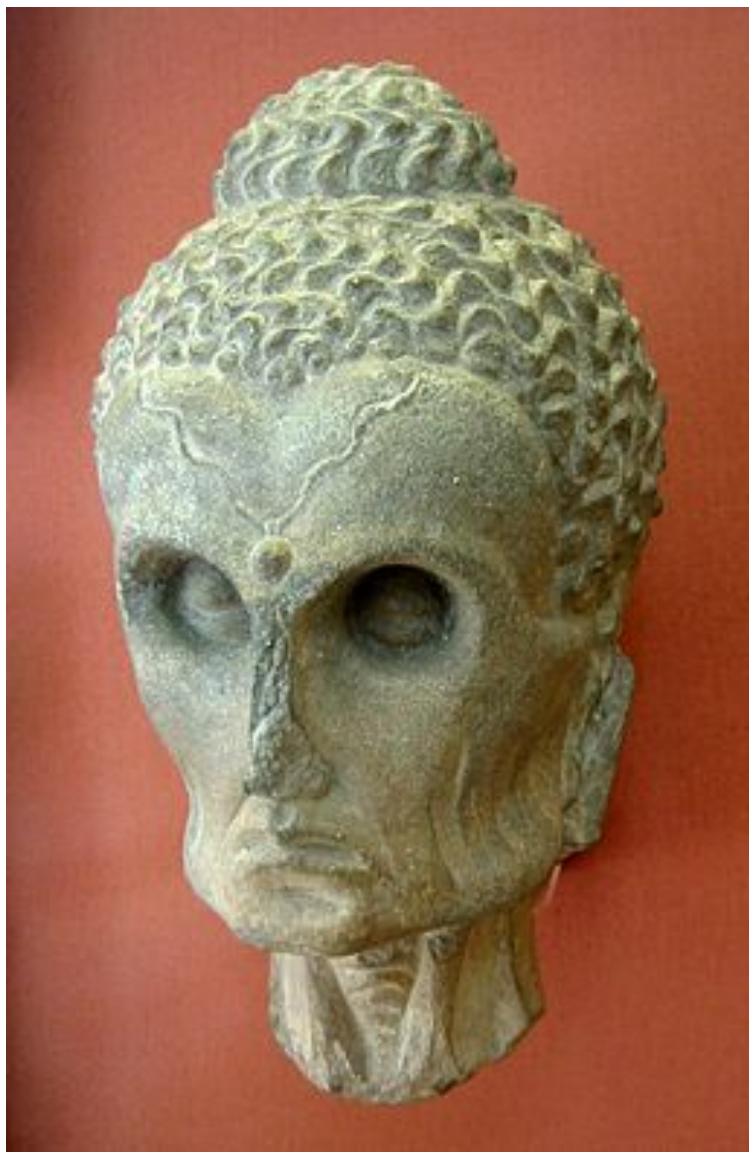
morbidity in humans as well. This is the concept of *healthspan*—"maintaining full functioning as nearly as possible to the end of life." (Rowe and Kahn, *Science*, 1987) Explain Allison et al (Smith et al, *European Journal of Clinical Investigation*, 2010), "...the academic or esoteric question of whether lifespan can be truly extended by CR in humans may not be as important as the potential prolongation of healthspan." Further, say Kirkland and Peterson, (*Journal of Gerontology: Biological Sciences*, 2009), who also emphasize the importance of healthspan, "It is not clear whether increasing lifespan will be associated with a pushing of morbidity out until near the end of life (compression of morbidity) or with increased disability and health care costs for society (expansion of morbidity.)"

The problem is that CR may be too difficult to implement in humans, and as Keys et al had noted, hunger does not seem to dissipate with CR, and humans complain of being lethargic, tired, and cold. (Speakman and Hambly, *Journal of Nutrition*, 2007) The goal may be, say Balasubramanian et al, (*Ebiomedicine*, 2017) to understand its mechanism, rather than "promote it as a lifestyle."

For example, there have been two human studies—the randomized controlled trials, CALERIE 1 and 2 (*Comprehensive Assessment of Long-term Effects of Reducing Intake of Energy*), to assess the physiological and psychological effects of CR on healthy, non-obese subjects. The researchers describe it as not exactly a clinical trial but rather "a model of a controlled experiment in free-living humans." (Stewart et al, *Contemporary Clinical Trials*, 2013) Initially the researchers had aimed for a 30 percent reduction in calories, but then realized that was not feasible and settled for 25 percent. By the end of the two years, though, CR was achieved at only 12 percent. (Das et al, *Molecular and Cellular Endocrinology*, 2017)

Bottom Line: There are several theories about the mechanisms involved in caloric restriction with adequate nutrition, but there remain many unanswered questions, such as how much CR is beneficial; when should it first be implemented, including ethical issues of starting when someone is too young (where CR may affect growth, development, and even reproduction when CR may lead to

amenorrhea in women) (Speakman and Hambly, 2007); and what are the most advantageous macronutrient percentages of fat, protein, and carbohydrate, i.e, the varying "dietary landscape." (Simpson et al, *Ageing Research Reviews*, 2017). Studies seem to demonstrate CR's efficacy in reducing age-related morbidities but for most, CR may not be feasible for the long term. Investigators are now studying compounds (e.g. resveratrol, rapamycin, metformin) to mimic the effects of CR. (Balasubramanian et al, 2017)



"Emaciated Buddha," Artist unknown. Date: circa between 100-299 A.D. British Museum, Department of Asia. (Collected Pakistan) Credit line: 1907: given by Colonel F.G. Mainwaring.

Source: Wikimedia Commons/Public Domain

Note: In recent years, Ancel Keys has been unfairly maligned for his work on the connection between heart disease and fat intake in his major *Seven Countries Study*. For a comprehensive discussion, see the *White Paper* available online by researchers Pett, Kahn, Willett, and Katz, *Ancel Keys and the Seven Countries Study: An Evidenced-based Response to Revisionist Histories*. (2017)

About the Author

Sylvia R. Karasu, M.D., is a clinical professor of psychiatry at Weill Cornell Medical College and the senior author of *The Gravity of Weight*.

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