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The Gravity of Weight

Body Weight in the Time of Climate Control

Creatures of comfort: Entering the monotony of the TNZ—the thermoneutral zone

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Honeywell round thermostat found in the Smithsonian Museum, Creative Commons Attribution, Flickr user midnightcomm.

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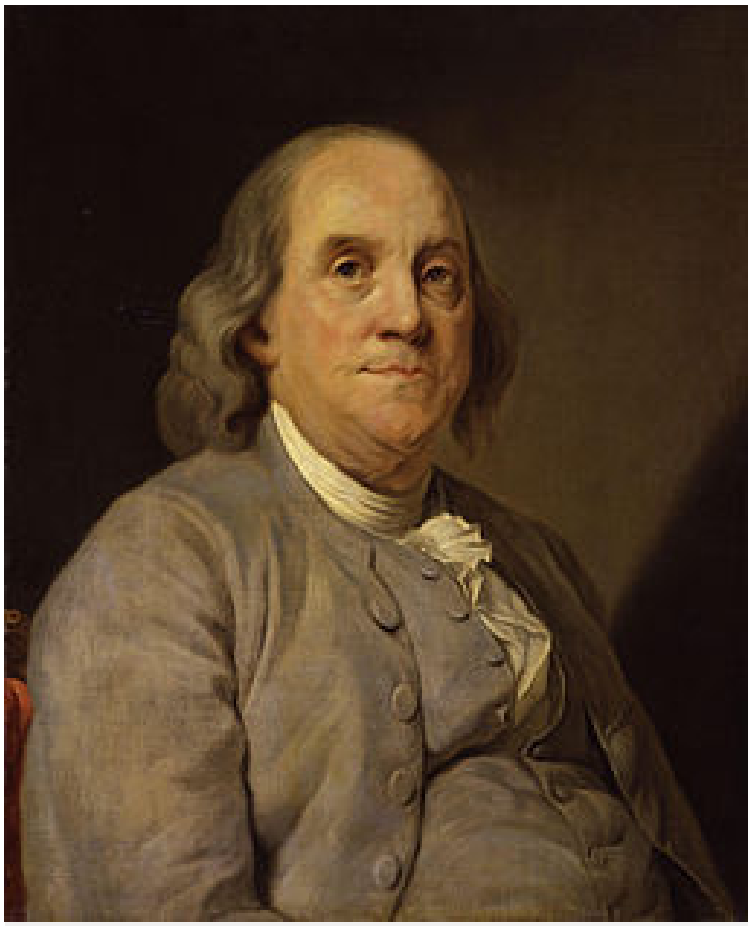
The heat in the unnamed Caribbean seaport in *Love in the Time of Cholera*, Gabriel García Márquez' steamy novel set in the last years of the 19th century and early years of the 20th, is "devastating," "sweltering," "infernal," "deadly," "suffocating," "dusty" and "blazing." Likewise, Harper Lee, in her powerful classic *To Kill a Mockingbird*, set in Alabama in 1932, describes "men's stiff collars wilted by nine in the morning…(and) Ladies bathed before noon…by nightfall were like soft teacakes with frosting from sweating and sweet talcum." These were the years before air conditioning became commonplace. In each novel, the external heat is an insidious and dramatic backdrop for the subsequent unfolding events.

History is replete with examples of human attempts to control our ambient environment. In the 18th century, even American diplomat, scientist and inventor Benjamin Franklin became interested in the mechanisms for cooling our bodies. In a letter written in 1758 (June 17th, in Franklin, *Experiments and Observations on Electricity*) to Scottish-born physician John Lining—who was



American inventor Benjamin Franklin, who became interested in how the body cooled itself. Portrait by Joseph Duplessis (circa 1785), National Portrait Gallery, Washington

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himself interested in metabolism and famous for being the first to report on yellow fever in the colonies and to keep *A Diary of Weather* (Mendelsohn, 1960—*Chicago Journal, History of Science),* Franklin speculated on the complex mechanisms (e.g. continual sweating and evaporation of the sweat) that the human body develops to cool itself. After one of his experiments involving ether and "spirits," Franklin wrote to Lining, "…one may see the possibility of freezing a man to death on a warm summer's day."

Though there were earlier precursors, the modern thermostat, an automatic device for regulating temperature around a setpoint, was patented as a "heat governor" by a Scottish scientist Andrew Ure in the 1830s. (*Oxford English Dictionary*) The "air conditioning revolution," itself developed slowly over about the past 70 years, though there were earlier unsuccessful attempts. (Arsenault, *The Journal of Southern History,* 1984.) Engineer Willis H. Carrier is considered the inventor of the world's first air-conditioning system (controlling both temperature and humidity) at the turn of the 20th century, and according to Arsenault, Carrier's "ingenuity and vision" guided the industry for the next fifty years.

Initially air conditioning was used primarily in industries to standardize the working environment. Later, movie theaters, railroad cars, and banks were air-conditioned. Air conditioning in hospitals did not begin to become more common until the 1940s and 1950s, and air-conditioned automobiles, after World War II. Most courthouses and federal buildings in the South did not have air conditioning until the 1950s. (Remember the scene of the almost palpable sweltering heat in the un-air-conditioned courtroom of the film version of *To Kill a Mockingbird*.) Arsenault notes that by 1955 one out of every twenty-two American homes had air conditioning, and one out of ten in the South, and once air conditioning "invaded the home and automobile, there was no turning back." He credits air conditioning with changing the southern way of life, "influencing everything from architecture to sleeping habits."

In the South, with some of the highest rates of obesity in the U.S., central air conditioning increased in from 37 to 70% of homes just between 1978 and 1997 (Keith et al, *International Journal of Obesity*, 2006); by 1997, 93% of Southern households had some form of air conditioning. (Healy, *Building Research &*

Information, 2008) U.S. census data for the presence of air conditioning in completed new single family homes in the U.S. found 49% in 1973 and 91% by 2014.

Willis Carrier, 1915. Photo from the Carrier Corporation. Cornell engineer Carrier is credited with designing the first air conditioning system.

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Healy (2008) writes of the "thermal monotony" or "homogeneity" of air-conditioned environments that we create "via scientifically delineated norms of thermal comfort" throughout the world. Johnson et al (*Obesity Reviews*, 2011) note that we now have "increased expectations of thermal comfort." For example, not only have bedroom temperatures increased over the decades but also hallways and other rooms are more likely than in the past to be kept at homogeneous temperatures. Further, temperatures in the workplace have increased.

Does all this homogeneity of our ambient environment have an effect on us? Being homeothermic, we humans are able to maintain a fairly stable body temperature (around 37 degrees Centigrade, or 98.6 Fahrenheit), despite the air temperature around us. This ability, though, comes at a metabolic cost—it requires energy. When humans are exposed to cold, they conserve heat by peripheral vaso-constriction; they also may begin shivering that entails an increase in energy expenditure—generating heat through involuntary contraction of skeletal muscles. There is also non-shivering or so-called "adaptive thermogenesis" that defends body temperature by generation of heat in tissues, and is also initiated by eating. Diet-induced thermogenesis is the "energy cost" involved in the digestion and absorption of food. Further, metabolically active brown fat, once thought to be present only in infants (and is responsible for their not shivering), is now thought to play a much greater role in thermogenesis than once believed. It appears in adult humans with mild cold exposure. For more on brown fat, see my previous blog: https://www.psychologytoday.com/blog/the-gravity-weight/201205/special-d....

There is the suggestion that there are seasonal differences in the prevalence of active brown fat. Furthermore, Gerhart-Hines and Lazar (*Endocrine Reviews*, 2015) suggest that brown fat is under circadian rhythm control, and they hypothesize that the circadian clock was evolutionarily programmed to "turn off" brown adipose tissue during sleep when most animals are in a shielded environment. Now with a

24/7 lifestyle of highly caloric diets eaten later, there may be less calorie burning at night. Johnson et al (2011) maintain that as we seek "thermal comfort" and have less exposure to cold, we will reduce the frequency and duration of occasions when "cold-induced expenditure" (e.g. brown fat) is utilized.

View of the Sistine Chapel, Vatican, by Michelangelo. The Carrier Corporation was requested to help preserve this masterpiece by designing a groundbreaking heating, ventilating, and air conditioning system in 1993.

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In an attempt to explain the burgeoning rate of overweight and obesity globally in recent years, researchers have begun to explore "the roads less traveled."(Keith et al, 2006, after poet Robert Frost) Since our genetics have not changed during this brief period in evolutionary history, investigators have focused primarily on the environmental effects of excessive caloric intake and decreased physical activity due to our sedentary lifestyles as possible contributions—the so-called "Big Two" to explain the rising obesity rates. (Keith et al, 2006) Increased energy intake and decreased energy expenditure, no doubt, have had a major impact, but there are many other "putative contributions" (Keith et al, 2006) that are "biologically plausible" explanations (Johnson et al, 2011.) Note that the operative word is "contribution" rather than "cause." No one, of course, really knows what factors are responsible for recent increases in "globesity." Allison and his colleagues, though, have written two exceptionally comprehensive reviews that suggest that exposure to environmental toxins (e.g. endocrine disruptors), medications that lead to weight gain, (e.g. antipsychotics and antidepressants) reduced smoking in the population, advanced maternal age, decreased sleep time, exposure to viruses, and for our purposes here, more time spent in what is called the *thermoneutral zone (TNZ)* (Keith et al, 2006; McAllister et al, *Critical Reviews in Food Science and Nutrition*, 2009) may be involved.

For humans, the thermoneutral zone is a range of ambient temperatures in which we do not need to utilize energy to maintain a constant body temperature, i.e., "thermal homeostasis." (Mavrogianni et al, *Indoor and Built Environment,* 2013) Daly (*Obesity*, 2014) maintains this zone is 25 to 30 degrees C (77-86 degrees F when *unclothed* or 20.3 to 23 C (68.54-73.4 degrees F for *clothed* humans, while Mavrogianni et al (2013) maintain that it is from 25 to 27 degrees C (77-80.6 degrees F) for *unclothed* humans. When we are not in this zone, either above or below it, our bodies require modifications in energy intake and expenditure. (McAllister et al, 2009) These investigators speculate that since we are spending considerably more time in environments of climate control (e.g. air conditioning and central heating) over the course of the past forty years that this may be one "modest, yet significant contributor to the recent increase in the prevalence of obesity."(McAllister et al, 2009) They have reviewed evidence from both animal and human studies. For

example, rats had more adipose tissue when raised in a thermoneutral environment than those rats raised at cooler temperatures whose bodies had to utilize energy to maintain their body temperature. Weight is often reduced when animals, including chicken, pigs, and cattle, are subjected to warmer temperatures, both because these animals eat less at high temperatures and there is an "increased metabolic cost" to maintain a constant body temperature under these conditions. Likewise, when humans are subjected to cooler ambient temperatures, their metabolic rate is lower and more subject to weight gain, and when they are subjected to higher ambient temperatures, they tend to eat less, have a higher metabolic rate, and lose weight. These effects, though, can be mitigated in the presence of highly palatable foods.

Paul Gauguin's "The Siesta," 1890s, Metropolitan Museum of Art. Even the traditional siesta is less common in some places because of air-conditioned, climate-controlled environments

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Back in 1981, Dauncey (*British Journal of Nutrition*) exposed nine women to two different temperatures (a month apart) in a controlled environment and concluded that environmental temperature may "play a more important role than was previously recognized in energy balance."

Over the years, large epidemiological studies have been conducted worldwide, including in England (Daly, *Obesity* 2014); Korea (Yang et al, *PLOS One*, 2015); Spain (Valdés et al, *Obesity*, 2014); and Nepal and Tibet (Sherpa et al, *International Journal of Environmental Research and Public Health*, 2010). Though different researchers have found significant associations between obesity and ambient temperature, they acknowledge they cannot determine a cause-effect relationship since most studies are cross-sectional and do not account for whether subjects had moved to or from other areas. Further, often the studies rely on potentially unreliable self-report of activity levels and diet. In one study, subjects reported lower indoor temperatures than assessed by thermostat verification. Discrepancies among studies may be reflective of different ranges in mean temperatures, different altitudes (e.g. low oxygen levels at higher altitudes), different ethnic groups that are not representative of diverse populations, or even unspecified confounding variables, as well as methodological differences in data collection. Most of studies done have been in residential rather than work environments (Moellering and Smith, *Current Obesity Reports*, 2012) Furthermore, these authors note there are many factors that influence temperature perception such as air speed, humidity, body size, age, body fat, clothing, diet, and activity, and we all have behaviors to deal with uncomfortable temperatures, such as by donning protective clothing in winter. No single temperature is perfect for everyone.

Thermal control, though, is a "socio-cultural construct." (Mavrogianni et al, *Indoor and Built Environment*, 2013) These authors note that due to climate change, it is likely that outdoor ambient temperatures will

increase and reduce heating demand in the winter and increase cooling demand in the summer. They are apprehensive that as people become used to certain comfort, they will become less adaptable to changes in temperature in the future and prefer a "narrower" range of comfort.

Pieter Bruegel the Elder: "The Hunters in the Snow (Winter)," 1565, Kunsthistorisches Museum, Vienna. As we spend more time in climate-controlled environments, we may be exposed much less to naturally cold weather.

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Bottom Line: How and to what extent almost continuous exposure to climate-controlled ambient temperatures affects us, particularly our body weight, remains open to question. Ambient temperature can clearly affect both energy intake and energy expenditure but may affect people differently. Moellering and Smith (2012) believe that we need more studies that reflect the "daily cycles" of life as compared to the artificial environments of clinical laboratories. These researchers suggest that just as we need exposure to variable diets for health, so too perhaps we need exposure to a varied, natural range of ambient temperatures.

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.*

In Print: *The Gravity of Weight: A Clinical Guide to Weight Loss and Maintenance*

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