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The Gravity of Weight

Salt Intake: Taking Advice With That Proverbial Grain

Is there a salt setpoint for optimal health?

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Sixty-year-old Mahatma Gandhi led his followers on his 240-mile "Salt Satyagraha"in 1930 to protest British Colonial regulations in India. This Salt March Statue is in Delhi.

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Sixty-year-old Mahatma Gandhi, provoked by British regulations that prevented Indians from producing or selling their own local salt and that required them to purchase expensive, imported salt they could ill afford, led a group on a 240-mile march (*Salt Satyagraha*) in 1930 through a swath of western India to the Arabian Sea. Picking up “handfuls of salt along the shore,” he and his followers thus “technically produced salt” and disobeyed Colonial law. (Pletcher, *Britannica.com*, 2015) This defiance, which led to his arrest and imprisonment, was considered Gandhi’s first major step in his campaign of civil disobedience against British rule in India. (Pletcher, 2015)

History, from very ancient to modern times, is replete with examples of the importance of salt as a precious and versatile commodity. (For a breezy overview, see Kurlansky, *Salt: A World History,* 2002) For at least 5000 years, the Chinese appreciated the food preservative qualities of salt. (Ha, *Electrolytes & Blood Pressure*, 2014) In Roman times, it was used for trade: the Latin word “salarium,” from which our word ‘salary,’ is derived was the “money allowed to Roman soldiers to purchase salt.” (*Oxford English Dictionary*) And throughout history, people have been willing, like Gandhi, to take a stand against salt’s unjust restriction. There are even some who believe the tax on salt (the *gabelle*), initiated centuries earlier, (Denton, *The Hunger for Salt,* p. 84, 1984) was one factor that ultimately led to the French Revolution. (Cirillo, *American Journal of Nephrology*, 1994)

Mount Sodom, Israel, showing the so-called "Lot's Wife" pillar.

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Even the Bible has multiple references to salt. Perhaps most famous is The Old Testament's story of Lot's wife, who disobeys God's prohibition to look back on the fire and brimstone destruction of Sodom and is turned instantly into a pillar of salt. (Genesis 19: 15-26) (For those interested, see scientific articles on "The chemical death of Lot's wife" in a 1988 issue, *Journal of the Royal Society of Medicine.*) In The New Testament, Jesus says of his followers, "You are the salt of the earth" in his "Sermon on the Mount." (Matthew 5:13)

More recently, our English language is "peppered," if you will, with expressions involving salt. For example, being "worth one's salt" indicates competence or efficiency; "rub salt in one's wounds" means, "adding more pain to injury"; and "take with a grain of salt," suggests, "be skeptical." Even The Rolling Stones wrote the song "Salt of the Earth" for their 1968 album *Beggars Banquet*.

What then exactly is salt? For our purposes, common table salt is sodium chloride (40% sodium, 60% chloride) (Ha, 2014). Sodium is an "essential nutrient" and an important regulator of bodily fluids. Though Gandhi had used his "Salt March" for political purposes, he intuitively knew his physiology, "Next to air and water, salt is perhaps the greatest necessity of life," he wrote. (*Mahatma, Life of Gandhi*, Chapter 5, *The Epic March*, Commentary, Reel 11) Either too little (i.e., *hyponatremia)* or too much sodium (i.e., *hypernatremia*), such as can occur through excessive vomiting, sweating, dehydration, or diarrhea, can be potentially life threatening. About 90% of the sodium we eat daily is excreted in our urine. (O'Donnell et al, *Circulation Research*, 2015) The amount of sodium is tightly regulated, and the kidney is central to maintaining sodium levels by a complex system involving aldosterone, angiotension II, and renin, as well as the activation

"Lot's Wife" artistically rendered by William Hamo Thornycroft, 1877, Victoria & Albert Museum, London. (Creative Commons Attribution)

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of the sympathetic nervous system. (Mancia et al, *European Heart Journal*, 2017)

Sodium can come from *discretionary* sources (e.g. salt added in cooking or by an individual during a meal) and *non-discretionary* sources (e.g. processed or pre-prepared foods.) In fact, about 80% of our daily sodium intake now comes from processed foods. (Taormina, *Critical Reviews in Food Science and Nutrition*, 2010) Further, there are many other compounds that contain sodium that enter our food supply, such as monosodium glutamate (MSG), sodium citrate, sodium nitrite, sodium benzoate, sodium bicarbonate, and sodium propionate, all of which have been used as food preservatives and have appeared as ingredients in processed foods. (Taormina, 2010)

In recent years, refrigeration helps preserve food, but for centuries, sodium chloride had been and remains one of the most effective agents against many bacteria (e.g. botulin toxin and E. coli) and even some viruses “and remains one of the most effective tools for the development of safe and wholesome food products.” (Taormina, 2010) Salt is not only an important preservative, but it enhances flavor and can change the texture, consistency, and even moisture content of food (Taormina, 2010) For example, salt, by increasing the amount of water in meat, can increase its weight as much as 20%. (He and MacGregor, *Journal of Human Hypertension*, 2009) Salt can also aid in the process of fermentation.

Most people can handle substantial daily variations in sodium intake without any difficulty. Some, though, are more “salt-sensitive” than others. There is no consistent definition for salt-sensitivity. Blood pressure response to salt consumption varies among individuals: according to the response, some are considered *salt-sensitive* and some others are *salt-resistant.* In the total population, 51% of those patients with hypertension are salt-sensitive, and among normotensives, 26% are salt-sensitive. Risk factors for salt-sensitivity include black race, intrinsic kidney disease, and aging. (Delahaye, *Archives of Cardiovascular Disease*, 2013) Rust and Ekmekcioglu (*Advances in Experimental Medicine and Biology,* 2016) note that salt-sensitivity in normotensive adults predicts future hypertension and has been associated with increased

mortality in both normotensive and hypertensive persons. For those salt-sensitive, there is a recommendation to increase potassium consumption as well as reduce sodium intake. (Rust and Ekmekcioglu, 2016).

Piles of salt in Bolivia taken by LucaG.

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But despite that sodium chloride is "indispensible for life" for our body's homeostasis, salt has "attained the status of a villain, if not a poison" in the past century. (Drüeke, *Kidney International*, 2016) For example, in a recent study that received media attention, high sodium intake became "a key target" among the ten foods and nutrients that were studied and was implicated in the death of over 66,500 Americans in 2012—"the largest number of estimated diet-related cardiometabolic deaths." (Micha et al, *JAMA*, 2017) The authors did acknowledge they could not prove causality, and the researchers also appreciated that their "risk assessment does not prove that changes in dietary habits reduce disease risk." Further, this study did not actually measure sodium intake accurately.

The so-called "villainization" of salt grew out of research, both in animals and humans, from the 1940s and 1950s that implicated excessive sodium as a possible cause of hypertension. (Drüeke, 2016) Over the years, though, randomized controlled trials analyzing the role of lowering salt intake to decrease blood pressure have had conflicting results, often because of small samples and studies of short duration, often lasting less than six months. (Mancia et al, 2017) Furthermore, many of these studies could not separate out the effects of sodium specifically from other dietary factors, including potassium intake from fruits and vegetables, physical activity, and even excessive alcohol use that may also impact blood pressure. (Drüeke, 2016; Mancia et al, 2017) Further, obtaining sodium exposure from fresh fish is presumably different from exposure from highly processed "junk food."

In general, human and animal studies now support the concept that *excessive* salt intake is a major factor that increases blood pressure in the general population and reducing salt intake can lower blood pressure in many people. (He and MacGregor, *Journal of Human Hypertension*, 2009; Mancia et al, 2017) The mechanisms by which salt increases blood pressure are not completely elucidated: the kidneys, central nervous system, vasoactive substances, and neurohumoral factors are all involved. (Delahaye, 2013.)

Much of the support for the idea that a low sodium diet leads to lower blood pressure comes from the Dietary Approaches to Stop Hypertension (*DASH*) that enrolled over 400 people and randomly assigned them to different levels of sodium intake. The DASH diet, though, was significantly different from the control

diet, and contained more fruits, vegetables, low-fat dairy, whole grains, less red meat and fewer sweets, etc. (DiNicolantonio et al, *American Journal of Medicine*, 2013) In another study (TOHP-II, with over 2300 subjects and follow-up of 36 months), different diets were also used, and the intervention cohort, for example, was advised to use more spices, use of which may have its own effects. (DiNicolantonio et al, 2013)

Lot leaving Sodom. Woodcut from the Nuremberg Chronicle. The story of Lot from Genesis is a popular theme in art.

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Researchers even note there is no conclusive evidence that a low sodium diet reduces the possibility of cardiovascular events in those patients who do not have hypertension, and they suggest that lowered sodium intake can even worsen those with congestive heart failure or type 2 diabetes. (DiNicolantonio et al 2013) Likewise, Mente et al (*The Lancet,* 2016) found there is a "U shaped curve, with evidence of increased risk of cardiovascular events with sodium excretion *lower* than 3 grams/day in those with and without hypertension, but the harm associated with high sodium consumption (greater than 6 grams/day) *seems to be confined to those individuals with hypertension*. These investigators believe "this argues against a population-wide recommendation to reduce sodium intake in most countries,"(Mente et al 2016) and it is "prudent" to recommend reduced sodium intake only in those with high sodium intake and hypertension. Further, the essential nutrient iodine is often added to table salt; lowering sodium intake may lead to depleted iodine reserves that can lead to thyroid disorders.

Researchers also found that there may be a diminishing effect of lowering sodium intake on blood pressure over time, and adherence to low sodium intake may not be sustainable over the long term. (O'Donnell et al, 2015) Further, investigators have found there is considerable variation in the amount of sodium intake worldwide: the INTERSALT study, for example, (involving over 10,000 subjects in 32 countries) found people in Northern China had the highest level of sodium excretion. (O'Donnell et al, 2015)

The gold standard for quantifying sodium is measuring its excretion in *repeated* 24-hour collections of urine. Day-to-day variations can be as much as 20%. (Kong et al, *Frontiers in Endocrinology*, 2016) Rarely do studies collect 24-hour urine more than once, and most studies rely on *self-report* (e.g. food frequency questionnaires or 24-hour food diaries) that are *notoriously inaccurate* in all nutrition research but particularly in these studies because there are so many hidden sources of sodium in food. (Mancia et al, 2017; He and MacGregor, 2009; Rust and Ekmekcioglu, 2009) Another complication is that there may be circadian rhythms involved in sodium storage not captured by these measurements. (O'Donnell et al, 2015)

Despite considerable clinical research, researchers cannot even agree on the range of sodium intake that is considered normal or adequate: clearly sodium is essential and beneficial, but how much is harmful? Rozin and colleagues (*Health Psychology*, 1996) note we use simplistic, categorical thinking in nutrition: foods are either "good or bad for health," and we have "dose insensitivity," i.e., "the belief that if something is harmful in high amounts, it is also harmful in low or trace amounts." They also found evidence in nutritional research of *monotonic thinking,* i.e., that we are reluctant to accept the idea that low and high doses may have opposite effects. "Salt is frequently considered 'bad' and in large quantities that is often true; but, just because a lot of salt is bad does not mean that a little salt is bad." (Brown and Brown, in *Nutrition in Lifestyle Medicine*, 2017, J. M. Rippe, editor)

For sodium intake, the World Health Organization recommends less than 2000 mg/day; the American Heart Association, less than 1500 mg/day; and a 2013 evidenced-based report by the Institute of Medicine 2013 suggests there is "insufficient evidence to reduce sodium to below 2300 mg/day." The average intake of sodium hovers around 3400 mg/day or 8.5 g/salt in Canada, US, and UK. (DiNicolantonio and O'Keefe, *Progress in Cardiovascular Diseases*, 2016) (To obtain the amount of salt, multiply the amount of sodium in grams by 2.5; according to the American Heart Association, 1 teaspoon of salt equals 2300 mg sodium.)

One of the most ornate salt cellars ever made, by Benvenuto Cellini, 1540-1543, Kunsthistorisches Museum, Vienna.Photographer: Jerzy Strzelecki,Creative Commons Attribution.

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Swedish researcher Folkow (*Lakartidningen*, 2003) believes there is actually a "*biologically determined setpoint"* for salt intake—what he calls our "salt appetite" of 10 grams/day that is not reflective of "hedonistic abuse," when researchers consider both blood pressure and heart rate and this may be physiologically driven. He does support labeling the amount of salt in processed food and keeping it low, since "salt is easy to add but impossible to remove." Most other researchers recommend a considerably lower amount of 3-to-5 grams/day as optimal for cardiovascular health and believe that studies are too inconsistent to warrant decreases below 2 grams of sodium/day. (DiNicolantonio and O'Keefe, 2016; O'Donnell et al, 2015) Further, a meta-analysis of almost 170 studies found that sodium restriction lowers BP only by 1 to 3% in those without hypertension and 3.5 to 7% in those with hypertension, and some believe we may have "incriminated the wrong white crystals:" *sugar*, rather than salt, may be more detrimental and may "potentiate" the effects of salt, particularly in those who are salt-sensitive. (DiNicolantonio and O'Keefe, 2016)

Increased salt intake has been correlated with several pathological conditions, such as osteoporosis, obesity, and diabetes. For example, when salt intake is increased, there is an increased calcium loss in the urine, leading to a negative calcium balance that may predispose to greater bone loss. (Caudarella et al, *Journal of Endocrinological Investigation*, 2009; He and MacGregor, 2009) The relationship to obesity is complex and may be indirect: salt increases thirst that may then be quenched with highly caloric, sugary soft drinks. (He and MacGregor, *Pflügers Archiv, European Journal of Physiology,* 2015) Ma et al (*Hypertension*, 2015), though, did find a direct association between salt intake and obesity independent of energy intake: there is a suggestion that higher salt intake may lead to altered fat metabolism and increased fat deposition. Moosavian et al, (*International Journal of Food Sciences and Nutrition*, 2017) reviewed 18 cross-sectional studies and found an association between sodium intake and greater body mass index (BMI) and waist circumference, but conceded that they could not determine any "dose-response" association; further, some studies had not even measured sodium intake accurately, and unhealthy behaviors associated with obesity may be confounders. A recent study Radzeviciene and Ostrauskas (*Nutrients*, 2017) found a two-fold increase in diabetes in those who added salt to prepared meals, but used self-report measures.

Another artistic rendition of the story of Lot, his wife who turns to a pillar of salt, and his daughters who escape. Sodom Monreal, Dom von Monreale, Sizilien.

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Jaenke et al (*Critical Reviews in Food Science and Nutrition*, 2016) evaluated salt-reduced foods to assess the "extent to which salt could be reduced …without jeopardizing consumer acceptability." These investigators found that salt could be reduced in breads by up to 37% and in processed meats up to 67%. When sodium is reduced, though, foods can become bitter. Often potassium is used as a substitute, but for example, when used in cheeses, where salt is used in the process of ripening, it can lead to a sour taste. (Rust and Ekmekcioglu, 2016) Our salt taste receptors on our tongue, though, can become more or less sensitive to lower salt exposure over time.

Bottom line: Guidelines for salt restriction are inconsistent, and studies are often methodologically flawed. There continues to be controversy and a lack of agreement about what level of salt intake is beneficial, and reducing salt intake may have its own harmful consequences. To date, there are *no randomized controlled trials that conclusively* demonstrate that moderate or lower reductions in salt intake actually reduce cardiovascular disease; (Mancia et al, 2017) blood pressure is, after all, only a "surrogate endpoint" for cardiovascular morbidity. (Kong et al, 2016) Weill Cornell Professor of Medicine Dr. Alan M. Weinstein adds, "If there were a clear risk for sodium intake to

limit life expectancy, then good science should provide an estimate of that increased risk. I am not aware of any such estimate."

Note: For those interested, see Bisaccia et al's article, "The Symbolism of Salt in Paintings" in an issue of *The American Journal of Nephrology,* 1997.

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

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