Salt, energy, metabolic rate, and longevity

From the original article in 2007. Author: Ray Peat.

In the 1950s, when the pharmaceutical industry was beginning to promote some new chemicals as diuretics to replace the traditional mercury compounds, Walter Kempner's low-salt "rice diet" began to be discussed in the medical journals and other media. The diuretics were offered for treating high blood pressure, pulmonary edema, heart failure, "idiopathic edema," orthostatic edema and obesity, and other forms of water retention, including pregnancy, and since they functioned by causing sodium to be excreted in the urine, their sale was accompanied by advising the patients to reduce their salt intake to make the diuretic more effective.

It was clear to some physicians (and to most veterinarians) that salt restriction, especially combined with salt-losing diuresis, was very harmful during pregnancy, but that combination became standard medical practice for many years, damaging millions of babies.

Despite numerous publications showing that diuretics could cause the edematous problems that they were supposed to remedy, they have been one of the most profitable types of drug. Dietary salt restriction has become a cultural cliché, largely as a consequence of the belief that sodium causes edema and hypertension.

Salt restriction, according to a review of about 100 studies (Alderman, 2004), lowers the blood pressure a few points. But that generally doesn't relate to better health. In one study (3000 people, 4 years), there was a clear increase in mortality in the individuals who ate less salt. An extra few grams of salt per day was associated with a 36% reduction in "coronary events" (Alderman, et al., 1995). Another study (more than 11,000 people, 22 years) also showed an inverse relation between salt intake and mortality (Alderman, et al., 1997).

Tom Brewer, an obstetrician who devoted his career to educating the public about the importance of prenatal nutrition, emphasizing adequate protein (especially milk), calories, and salt, was largely responsible for the gradual abandonment of the low-salt plus diuretics treatment for pregnant women. He explained that sodium, in association with serum albumin, is essential for maintaining blood volume. Without adequate sodium, the serum albumin is unable to keep water from leaving the blood and entering the tissues. The tissues swell as the volume of blood is reduced.

During pregnancy, the reduced blood volume doesn't adequately nourish and oxygenate the growing fetus, and the reduced circulation to the kidneys causes them to release a signal substance (renin) that causes the blood to circulate faster, under greater pressure. A low salt diet is just one of the things that can reduce kidney circulation and stimulate renin production. Bacterial endotoxin, and other things that cause excessive capillary permeability, edema, or shock-like symptoms, will activate renin secretion.

The blood volume problem isn't limited to the hypertension of pregnancy toxemia: "Plasma volume is usually lower in patients with essential hypertension than in normal subjects" (Tarazi, 1976).

Several studies of preeclampsia or toxemia of pregnancy showed that supplementing the diet with salt would lower the women's blood pressure, and prevent the other complications associated with toxemia (Shanklin and Hodin, 1979).

It has been known for many years that decreasing sodium intake causes the body to respond adaptively, increasing the renin-angiotensin-aldosterone system (RAAS). The activation of this system is recognized as a factor in hypertension, kidney disease, heart failure, fibrosis of the heart, and other problems. Sodium restriction also increases serotonin, activity of the sympathetic nervous system, and plasminogen activator inhibitor type-1 (PAI-1), which contributes to the accumulation of clots and is associated with breast and prostate cancer. The sympathetic nervous system becomes hyperactive in preeclampsia (Metsaars, et al., 2006).

Despite the general knowledge of the relation of dietary salt to the RAA system, and its application by Brewer and others to the prevention of pregnancy toxemia, it isn't common to see the information applied to other problems, such as aging and the stress-related degenerative diseases.

Many young women periodically crave salt and sugar, especially around ovulation and premenstrually, when estrogen is high. Physiologically, this is similar to the food cravings of pregnancy. Premenstrual water retention is a common problem, and physicians commonly offer the same advice to cycling women that was offered as a standard treatment for pregnant women--the avoidance of salt, sometimes with a diuretic. But when women premenstrually increase their salt intake according to their craving, the water retention can be prevented.

Blood volume changes during the normal menstrual cycle, and when the blood volume is low, it is usually because the water has moved into the tissues, causing edema. When estrogen is high, the osmolarity of the blood is low. (Courtar, et al., 2007; Stachenfeld, et al., 1999). Hypothyroidism (which increases the ratio of estrogen to progesterone) is a major cause of excessive sodium loss.

The increase of adrenalin caused by salt restriction has many harmful effects, including insomnia. Many old people have noticed that a low sodium diet disturbs their sleep, and that eating their usual amount of salt restores their ability to sleep. The activity of the sympathetic nervous system increases with aging, so salt restriction is exacerbating one of the basic problems of aging. Chronically increased activity of the sympathetic (adrenergic) nervous system contributes to capillary leakage, insulin resistance (with increased free fatty acids in the blood), and degenerative changes in the brain (Griffith and Sutin, 1996).

The flexibility of blood vessels (compliance) is decreased by a low-salt diet, and vascular stiffness caused by over-activity of the sympathetic nervous system is considered to be an important factor in hypertension, especially with aging.

Pregnancy toxemia/preeclampsia involves increased blood pressure and capillary permeability, and an excess of prolactin. Prolactin secretion is increased by serotonin, which is one of the substances increased by salt restriction, but prolactin itself can promote the loss of sodium in the urine (Ibarra, et al., 2005), and contributes to vascular leakage and hypertension.

In pregnancy, estrogen excess or progesterone deficiency is an important factor in the harmful effects of sodium restriction and protein deficiency. A deficiency of protein contributes to hypothyroidism, which is responsible for the relative estrogen excess.

Protein, salt, thyroid, and progesterone happen to be thermogenic, increasing heat production and stabilizing body temperature at a higher level. Prolactin and estrogen lower the temperature set-point.

The downward shift of temperature and energy metabolism in toxemia or salt deprivation tends to slow the use of oxygen, increasing the glycolytic use of sugar, and contributing to the formation of lactic acid, rather than carbon dioxide. In preeclampsia, serum lactate is increased, even while free fatty acids are interfering with the use of glucose.

One way of looking at those facts is to see that a lack of sodium slows metabolism, lowers carbon dioxide production, and creates inflammation, stress and degeneration. Rephrasing it, sodium stimulates energy metabolism, increases carbon dioxide production, and protects against inflammation and other maladaptive stress reactions.

In recent years, Weissman's "wear-and-tear" theory of aging, and Pearl's "rate of living" theory have been clearly refuted by metabolic studies that are showing that intensified mitochondrial respiration decreases cellular damage, and supports a longer life-span.

Many dog owners are aware that small dogs eat much more food in proportion to their size than big dogs do. And small dogs have a much greater life expectancy than big dogs, in some cases about twice as long (Speakman, 2003).

Organisms as different as yeasts and rodents show a similar association of metabolic intensity and life-span. A variety of hamster with a 20% higher metabolic rate lived 15% longer than hamsters with an average metabolic rate (Oklejewicz and Daan, 2002).

Individuals within a strain of mice were found to vary considerably in their metabolic rate. The 25% of the mice with the highest rate used 30% more energy (per gram of body weight) than the 25% with the lowest metabolic rate, and lived 36% longer (Speakman, et al., 2000).

The mitochondria of these animals are "uncoupled," that is, their use of oxygen isn't directly proportional to the production of ATP. This means that they are producing more carbon dioxide without necessarily producing more ATP, and that even at rest they are using a considerable amount of energy.

One important function of carbon dioxide is to regulate the movement of positively charged alkali metal ions, such as sodium and calcium. When too much calcium enters a cell it activates many enzymes, prevents muscle and nerve cells from relaxing, and ultimately kills the cell. The constant formation of acidic carbon dioxide in the cell allows the cell to remove calcium, along with the small amount of sodium which is constantly entering the cell.

When there is adequate sodium in the extracellular fluid, the continuous inward movement of sodium ions into the resting cell activates an enzyme, sodium-potassium ATPase, causing ATP to break down into ADP and phosphate, which stimulates the consumption of fuel and oxygen to maintain an adequate level of ATP. Increasing the concentration of sodium increases the energy consumption and carbon dioxide production of the cell. The sodium, by increasing carbon dioxide production, protects against the excitatory, toxic effects of the intracellular calcium.

Hypertonic solutions, containing more than the normal concentration of sodium (from about twice normal to 8 or 10 times normal) are being used to rescuscitate people and animals after injury. Rather than just increasing blood volume to restore circulation, the hypertonic sodium restores cellular energy production, increasing oxygen consumption and heat production while reducing free radical production, improves the contraction and relaxation of the heart muscle, and reduces inflammation, vascular permeability, and edema.

Seawater, which is hypertonic to our tissues, has often been used for treating wounds, and much more concentrated salt solutions have been found effective for accelerating wound healing (Mangete, et al., 1993).

There have been several publications suggesting that increasing the amount of salt in the diet might cause stomach cancer, because countries such as Japan with a high salt intake have a high incidence of stomach cancer.

Studies in which animals were fed popular Japanese foods--"salted cuttlefish guts, broiled, salted, dried sardines, pickled radish, and soy sauce"--besides a chemical carcinogen, showed that the Japanese foods increased the number of tumors. But another study, adding only soy sauce (with a salt content of about 18%) to the diet did not increase the incidence of cancer, in another it was protective against stomach cancer (Benjamin, et al., 1991). Several studies show that dried fish and pickled vegetables are carcinogenic, probably because of the oxidized fats, and other chemical changes, and fungal contamination, which are likely to be worse without the salt. Animals fed dried fish were found to have mutagenic urine, apparently as a result of toxic materials occurring in various preserved foods (Fong, et al., 1979).

Although preserved foods develop many peculiar toxins, even fresh fish in the diet have been found to be associated with increased cancer risk (Phukan, et al., 2006).

When small animals were given a milliliter of a saturated salt solution with the carcinogen, the number of tumors was increased with the salt. However, when the salt was given with mucin, it had no cancer promoting effect. Since the large amount of a saturated salt solution breaks down the stomach's protective mucus coating, the stomach cells were not protected from the carcinogen. Rather than showing that salt causes stomach cancer, the experiments showed that a cup or more of saturated salt solution, or several ounces of pure salt, shouldn't be ingested at the same time as a strong carcinogen.

Some studies have found pork to be associated with cancer of the esophagous (Nagai, et al., 1982), thyroid (Markaki, et al., 2003), and other organs, but an experiment with beef, chicken, or bacon diet in rats provides another perspective on the role of salt in carcinogenesis. After being given a carcinogen, rats were fed meat diets, containing either 30% or 60% of freeze-dried fried beef, chicken, or bacon. Neither beef nor chicken changed the incidence of precancerous lesions in the intestine, but the incidence was reduced by 12% in the animals on the 30% bacon diet, and by 20% in rats getting the diet with 60% bacon. Salt apparently made the difference.

Other protective effects of increased sodium are that it improves immunity (Junger, et al., 1994), reduces vascular leakiness, and alleviates inflammation (Cara, et al., 1988). All of these effects would tend to protect against the degenerative diseases, including tumors, atherosclerosis, and Alzheimer's disease. The RAA system appears to be crucially involved in all kinds of sickness and degeneration, but the protective effects of sodium are more basic than just helping to prevent activation of that system.

A slight decrease in temperature can promote inflammation (Matsui, et al., 2006). The thermogenic substances--dietary protein, sodium, sucrose, thyroid and progesterone--are antiinflammatory for many reasons, but very likely the increased temperature itself is important.

A poor reaction to stress, with increased cortisol, can raise the body temperature by accelerating the breakdown and resynthesis of proteins, but adaptive resistance to stress increases the temperature by increasing the consumption of oxygen and fuel. In the presence of increased cortisol, abdominal fat increases, along with circulating fatty acids and calcium, as mitochondrial respiration is suppressed.

When mice are chilled, they spontaneously prefer slightly salty water, rather than fresh, and it increases their heat production (Dejima, et al., 1996). When rats are given 0.9 per cent sodium chloride solution with their regular food, their heat production increases, and their body fat, including abdominal fat, decreases (Bryant, et al., 1984). These responses to increased dietary sodium are immediate. Part of the effect of sodium involves regulatory processes in the brain, which are sensitive to the ratio between sodium and calcium. Decreasing sodium, or increasing calcium, causes the body's metabolism to shift away from thermogenesis and accelerated respiration.

Regulating intracellular calcium by increasing the production of carbon dioxide is probably a basic mechanism in sodium's protection against inflammation and excitatory cell damage and degeneration.

Cortisol's suppression of mitochondrial respiration is closely associated with its ability to increase intracellular calcium. Cortisol blocks the thermogenic effects of sodium, allowing intracellular calcium to damage cells. With aging, the tissues are more susceptible to these processes.

The thermogenic effects of sodium can be seen in long-term studies, as well as short. A low-sodium diet accelerates the decrease in heat production that normally occurs with aging, lowering the metabolic rate of brown fat and body temperature, and increasing the fat content of the body, as well as the activity of the fat synthesizing enzyme (Xavier, et al., 2003).

Activation of heat production and increased body temperature might account for some of the GABA-like sedative effects of increased sodium. Increasing GABA in the brain increases brown fat heat production (Horton, et al., 1988). Activation of heat production by brown fat increases slow wave sleep (Dewasmes, et al., 2003), the loss of which is characteristic of aging. (In adult humans, the skeletal muscles have heat-producing functions similar to brown fat.)

Now that inflammation is recognized as having a central role in the degenerative diseases, the fact that renin, angiotensin, and aldosterone all contribute to inflammation and are increased by a sodium deficiency, should arouse interest in exploring the therapeutic uses of sodium supplementation, and the integrated use of all of the factors that normally support respiratory energy production, especially thyroid and progesterone. Progesterone's antagonism to aldosterone has been known for many years, and the synthetic antialdosterone drugs are simply poor imitations of progesterone.

But the drug industry is interested in selling new drugs to block the formation and action of each of the components of the RAAS, rather than an inexpensive method (such as nutrition) to normalize the system.

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