REVIEW ARTICLE

Health Effects of Alkaline Diet and Water, Reduction of Digestive-tract Bacterial Load, and Earthing

Haider Abdul-Lateef Mousa, MB ChB, MSc

ABSTRACT

In the article, the author discusses the issue of chronic, low-grade acidosis that is thought to be brought about primarily by 2 factors: (1) advancing age, with a consequent decline in renal function; and (2) diet. An acid-forming diet can induce low-grade metabolic acidosis, which causes very small decreases in blood pH and plasma bicarbonate (HCO_3^-) that remain within the range considered to be normal. However, if the duration of the acidosis is prolonged or chronically present, even a low degree of acidosis can become significant. This article reviews supporting evidence in the literature that has shown that consumption of abundant alkaline-forming foods can result in improvement in bone mineral density (BMD) and muscle mass, protection from chronic illnesses, reduced tumor-cell invasion and metastasis, and effective excretion of toxins from the body. In addition, a large number of studies showing the benefits of alkaline-forming foods have revealed that people consuming water with a high level of total dissolved solids (TDS) (ie, with a high mineral content) have shown a lower incidence of coronary heart disease (CHD), cardiovascular disease (CVD), and cancer and lower total mortality rates. Consumption of alkaline water also may prevent osteoporosis and protect pancreatic beta cells with its antioxidant effects. In addition, this article discusses the literature that shows that reducing acid production by digestive-tract bacteria can play an important role in increasing blood alkalinity toward the normal upper limit. That change occurs through good oral hygiene, flossing of teeth, perfect chewing of food, and bowel evacuation as soon as possible. Finally, the author reviews the literature that shows that earthing (ie, the direct contact of the human body with the earth) can supply a current of plentiful electrons. Earthing has been shown to reduce acute and chronic inflammation, blood glucose in patients with diabetes, red blood cell (RBC) aggregation, and blood coagulation. It also has been shown to produce symptomatic improvement in chronic, muscle and joint pain, a reduction in overall stress levels and tensions, a boost in positive moods, an improvement in heart rate variability, and an improvement in the immune response. (*Altern Ther Health Med.* 2016;22(S1):##-##.)

Haider Abdul-Lateef Mousa, MB ChB, MSc, is a lecturer in the College of Medicine at the University of Basrah in Basrah, Iraq.

Corresponding author: Haider Abdul-Lateef Mousa, MB ChB, MSc
E-mail address: haideramousa@gmail.com

The human body tends to maintain a tightly controlled pH range of approximately 7.35 to 7.45 in the extracellular fluid through respiratory excretion of carbon dioxide and renal excretion of a noncarbonic (ie, a nonvolatile) acid or base.[1] Everyday metabolism produces acid as nonvolatile sulfate from amino-acid catabolism, nonmetabolized organic acids, and phosphoric and other acids. The kidney reabsorbs all of the filtered bicarbonate (HCO_3^-) and generates new HCO_3^- in the collecting duct. Under normal steady-state conditions, the net quantity of acid secreted and the consequent renal generation of new HCO_3^- equals the rate of metabolic proton generation, preserving pH balance.

In metabolic acidosis, either nonvolatile acid accumulates or HCO_3^- is lost (eg, in diarrhea) and that result can occur even when the plasma HCO_3^- is within the range considered to be normal (24-28 mmol/L).[2] An acid-forming diet can induce low-grade metabolic acidosis, which causes very small decreases in blood pH and plasma HCO_3^-, that remain within the range considered to be normal. Within that range, the system equilibrates nearer the lower end rather than the higher end of normal.

However, if the duration of the acidosis is prolonged or chronically present, even a low degree of acidosis can become significant. A less severe but more chronic, low-grade acidosis is thought to be brought about primarily by 2 factors: (1) advancing age, with a consequent decline in

renal function; and (2) diet, which may promote acidosis both by its net acid load and by its sodium-chloride content. With age, the severity of diet-dependent acidosis increases independently of the diet, most likely due to a decline in the kidney's functional capacity.[3-5] Renal insufficiency contributes to metabolic acidosis by reducing conservation of HCO_3 and excretion of acid.

With the agricultural revolution of the last 100 centuries and, even more recently, with the industrialization of the last 2 centuries, a decrease has occurred in potassium as compared with sodium in the diet, and an increase in chloride has also resulted as compared with HCO_3^-. Humans today have a diet poor in magnesium and potassium as well as in fiber and rich in saturated fat, simple sugars, sodium, and chloride as compared with the preagricultural period.[6] The ratio of potassium (K) to sodium (Na) has reversed; K/Na previously was 10 to 1, whereas the modern diet has a ratio of 1 to 3.[3]

It has been documented that severe forms of metabolic acidosis in children, such as renal tubular acidosis, are associated with low levels of growth hormone, with a consequent short stature. Correction of the acidosis with HCO_3^- or potassium citrate[3,7] has been found to raise levels of growth hormone remarkably and improve growth. The use of sufficient potassium bicarbonate in the diet to neutralize the daily net acid load in postmenopausal women has been shown to produce a significant increase in growth hormone and, consequently, of osteocalcin.[8] Improving levels of growth-hormone may improve quality of life and body composition, reduce cardiovascular risk factors, and even improve memory and cognition.[9]

The aim of the present article is to investigate the role of the use of an alkaline diet and alkaline water, of a reduction in acid formation by digestive-tract bacteria, and of earthing as natural means for health promotion and prevention of chronic illnesses. Those roles are selected as one topic because they are all natural and are interrelated, providing cumulative, powerful, and beneficial health effects. The author studied those effects using independent papers, and they were not investigated or reviewed together as a single interrelated subject. The implementation of those natural factors could be available to all people with a low cost. It may have significant interest for the whole world through a reduction of the high costs of treatment for chronic diseases.

The current review was conducted according to the guidelines for Meta-Analyses and Systematic Reviews of Observational Studies (MOOSE)[10] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[11] The National Library of Medicine (PubMed) database was searched from its earliest records through June 2015, using the keywords *alkaline diet*, *alkaline acid food*, *alkaline water*, *mineral water*, *drinking water*, *earthing*, *grounding*, and *blood pH*. The type of search used was limited to English-language studies. In addition, other related references were manually searched. The articles with positive and negative outcomes were included in the review to avoid any bias in the selection. The data were obtained from epidemiological studies, clinical trials, case-control studies, cohort studies, experimental studies, in vitro research, animal research, systematic reviews, meta-analyses, the World Health Organization's (WHO's) reports, and published books.

ALKALINE DIET

Most food has the potential to alter the body's pH. When digested, some foods leave acidic by-products in the body (ie, they are acid-forming foods); others leave alkaline by-products (ie, they are alkaline-forming foods). Acid-forming foods include most high-protein foods, such as meat, fish, and eggs and most legumes, such as beans and peas. Sugar, alcohol, and most grains are also acid forming. Alkaline-forming foods include nearly all vegetables and fruits, many nuts and seeds, and spices and are shown in Table 1, which lists the potential renal acid loads (PRALs) of various foods.[12]

The term *alkaline diet,* also known as the alkaline ash diet, alkaline acid diet, acid ash diet, and the acid alkaline diet, describes a group of loosely related diets based on the fact that certain foods can affect the acidity of body fluids, including the urine or blood and can, therefore, be used to treat or prevent diseases. Alkaline food sources or supplements are cations—sodium (Na^+), potassium (K^+), calcium (Ca_2^+), and magnesium (Mg_2^+)—that decrease calciuria and exert a protective effect on bone.[13,14] On the other hand, acid foods or supplemental sources are anions—phosphate (PO_4^-), sulfate (SO_4^-), chloride (Cl^-), and organic acids—that cause metabolic acidemia and increase calciuria when consumed in excess, which is harmful to bone health.[13,15,16]

Both sodium and potassium belong to the alkaline category; however, the movement of the ratio toward a higher potassium intake can have favorable health effects. According to the acid-ash hypothesis, protein and grain foods are detrimental to bone health because of production of sulfate and phosphate,[12,13] whereas fruit and vegetables are bone protective because of their potassium-organic-anion content.[17]

Whole grains in comparison with refined ones are rich in minerals (ie, are an alkaline source) and have vitamins that might have protective effects on bone. A recent Korean study investigated the role of consumption of whole grains, dairy products, and fruits on bone health.[18] It suggested that a high intake of those products may contribute positively to the bone health of the adult population. No further studies could be found regarding the different effects of refined and whole grains on bone health. Additional studies to investigate such effects are suggested.

Another study also concluded that excessive dietary protein from foods with a high potential renal-acid load adversely affects bone, unless buffered by the consumption of alkali-rich foods or supplements.[19] In vitro studies have shown that metabolic acidosis induces a calcium efflux from bone.[20] In animal and human studies, an acid environment has been associated with a negative calcium balance and increased bone resorption.[21,22] Further, any extracellular acidification enhances osteoclastic activity, which raises the

Table 1. PRALs of Selected Foods[11]

Food or Food Group	PRAL mEq of Cl^+ PO_4^+ SO_4^- Na^- K^- Ca^- Mg
Dairy	
Parmesan cheese	34.2
Processed cheese, plain	28.7
Cheddar, reduced fat	26.4
Hard cheese (average)	19.2
Fresh cheese (quark)	11.3
Cottage cheese, plain	8.7
Yogurt, whole milk	1.5
Ice cream	0.8
Whole milk	0.7
Buttermilk	0.5
Eggs	
Eggs, yolk	23.4
Eggs, white	1.1
Eggs, chicken whole	8.2
Meats	
Corned beef	13.2
Luncheon meat, canned	10.2
Turkey	9.9
Veal	9.0
Lean beef	7.8
Frankfurters	6.7
Sugars	
Sugar, white	-0.1
Honey	-0.3
Vegetables	
Cucumber	-0.8
Broccoli	-1.2
Tomato	-3.1
Eggplant	-3.4
Celery	-5.2
Spinach	-14.0
Fats and oils	
Butter	0.6
Margarine	-0.5
Olive oil	0.0
Fruits, nuts, and fruit juices	
Peanuts	8.3
Walnuts	6.8
Grape juice, unsweetened	-1.0
Orange juice, unsweetened	-2.9
Apples or apple juice, unsweetened	-2.2
Apricots	-4.8
Bananas	-5.5
Black currents	-6.5
Raisins	-21.0
Grains and grain products	
Brown rice	12.5
Rolled oats	10.7
Spaghetti, whole grain	7.3
Spaghetti, white	6.5
Cornflakes	6.0
Rice, white	4.6
Bread, rye flower	4.1
Bread, whole wheat	1.8
Legumes	
Lentils, green and brown	3.5
Green beans	-3.1
Fish	
Trout, brown	10.8
Cod fillets	7.1
Beverages	
Beer, pale	0.9
Cola	0.4
Beer, draft	-0.2
Wine, white	-1.2
Coffee infusion	-1.4
Wine, red	-2.4

Note: A negative PRAL score indicates that the food is basic or alkaline, and a positive PRAL score indicates that the food is acidic. A score of 0 indicates that the food is neutral.

Abbreviations: PRALs, potential renal acid loads; mEq, milliequivalents; Cl^+, chloride; $PO4^+$, phosphate; $SO4^-$, sulfate; Na^-, sodium; K^-, potassium; Ca^-, calcium; Mg, magnesium.

absorption and removal of osseous tissue.[23] In vitro tests of the alkaline-phosphatase activity of osteoblasts, which had peaked strongly near pH 7.4, was reduced 8-fold at pH 6.9.[24] Thus, in uncorrected acidosis, the deposition of alkaline mineral in bone by osteoblasts is reduced, and resorptive activity by osteoclasts is increased to maximize the availability of hydroxyl ions in solution to buffer protons.[24]

With a long-term, nutritional acidic load, pH is kept constant at the expense of bone, which delivers the buffering substances through bone resorption.[25] Acidosis was also found to exert a powerful, reciprocal, inhibitory effect on the mineralization of bone matrix by cultured osteoblasts. That effect was caused by increased alkaline-mineral solubility at a low pH, together with selective inhibition of alkaline phosphatase, which is required for mineralization. Therefore, diets or drugs that shift the acid-base balance in the alkaline direction might provide useful treatments for bone-loss disorders.[26]

In a study by Krieger et al,[27] metabolic acidosis, which occurs during renal failure, renal insufficiency, or renal tubular acidosis, was shown to result in a decreased systemic pH and was associated with an increase in excretion of urine calcium, which would come partly at the expense of bone-mineral stores. Administration of HCO_3^- for 3 months showed a favorable effect on bone resorption and calcium excretion. That finding suggests that increasing the alkali content of the diet may attenuate bone loss in healthy older adults.[28] Soft-drink consumption may have adverse effects on bone mineral density (BMD). Colas contain caffeine and phosphoric acid (H_3PO_4) and may adversely affect bone because they are acidic beverages. It has been found that intake of cola, but not of other carbonated soft drinks, was associated with low BMD in women.[29]

Evidence is increasing that consumption of a Western diet is a risk factor for osteoporosis through an excess acid supply, whereas fruits and vegetables balance the excess acidity, mostly by providing potassium and HCO_3^--rich

foods. Western diets consumed by adults produce approximately 50 to100 mEq acid per day; therefore, healthy adults consuming such a diet are at risk of chronic, low-grade metabolic acidosis, which worsens with age as a result of declining kidney function.[30] Supporting evidence is available that alkaline-forming foods and nutrients can help in bone maintenance. A balanced diet with abundant fruits and vegetables and adequate protein has been found to be important to BMD,[22] whereas among older adults, inadequate protein intake has been shown to cause a greater problem for bone health than protein excess.[31]

One study has revealed a small, but significant, positive association between a diet that is abundant in alkaline foods and muscle-mass indexes in healthy women; the result was independent of age, physical activity, and protein intake.[29] Thus, a higher intake of foods rich in potassium, such as fruit and vegetables, might favor the preservation of muscle mass in older men and women.[32,33]

Acid pH has been shown to stimulate tumor-cell invasion and metastasis in vitro and in vivo, whereas oral sodium bicarbonate ($NaHCO_3$) has been shown to increase the pH of tumors selectively and to reduce the formation of spontaneous metastases in mouse models of metastatic breast cancer. [34] Use of $NaHCO_3$ as a treatment regimen has been shown to increase the extracellular pH significantly but not the intracellular pH.[34]

The increasing dietary acid load in the modern diet can lead to a disruption in acid-alkaline homeostasis in various body compartments and, eventually, can result in chronic disease through repeated borrowing of the body's alkaline reserves. Adjustment of tissue alkalinity, particularly within the kidney's proximal tubules, can lead to a more effective excretion of toxins from the body. Metabolic detoxification using a high-vegetable diet in conjunction with supplementation with an effective alkalizing compound, such as potassium citrate, may shift the body's reserves to become more alkaline.[35]

ALKALINE (MINERAL) WATER

Total dissolved solids (*TDS*) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. In many developing countries with no clean water supplies, or with water that is high in salt or that has a high level of TDS, a trend has occurred for people to consume reverse osmosis (RO) water in which the TDS ranges from 80 to 110, with a pH ranging from 6.8 to 7.2. That water is relatively deficient in essential alkaline minerals as compared with water from natural springs or rivers. Further, most people think that water that is free of the taste of salt is the best, which is incorrect. People in some countries also have a tradition of collecting rainwater into reservoirs for drinking purposes. Such water has insufficient minerals and might be acidic as a result of carbon-dioxide dissolution (ie, carbonic-acid formation).

On the other hand, consumption of mineral water has increased prominently in the developed world.[36] Usually, the consumption of water with a high mineral component produces alkaline by-products in the blood. Concentrations of TDS from natural sources have been found to vary from fewer than 30 mg/L (TDS, 30) to as many as 6000 mg/L (TDS, 6000), depending on the solubility of minerals in different geological regions.[37] According to WHO criteria, the optimum pH of drinking water is often in the range of 6.5 to 9.5.

The principal constituents of TDS are usually cations—calcium, magnesium, sodium, and potassium; and anions—carbonate, hydrogencarbonate, chloride, sulfate, and nitrate.[38] Natural mineral water differs from other bottled waters by its specific geological underground origin; it has a stable composition of minerals and original purity.[39] Natural mineral water must be bottled at the source to avoid any alteration in its chemical properties. Alkalinizing mineral waters can influence the acid-base equilibrium of the body by which even small changes in pH can have significant effects on cellular function.[40]

In previous studies, higher TDS concentrations in drinking water were associated with a lower incidence of coronary heart disease (CHD),[41] arteriosclerotic heart disease,[42] cardiovascular disease (CVD),[43,44] and cancer.[45] Lower total-mortality rates have been reported with higher TDS levels in drinking water.[44,46]

A meta-analysis of case-control studies also found significant evidence for an inverse association between magnesium levels in drinking water and cardiovascular mortality.[47] A review by Monarca et al[48] investigated all of the articles that had been published from 1980 to 2003. It demonstrated an inverse association between water hardness and mortality from CVD. It has shown that most case-control studies and one cohort study have revealed an inverse relationship that is statistically significant between mortality from CVD and levels of magnesium, but not calcium, in the water.[48] Another recent study also suggested favorable protective effects against CVD for water hardness, mainly due to the content of magnesium in the water.[49] Information from epidemiological and other studies supports the hypothesis that a low intake of magnesium may increase the risk of dying from, and possibly of developing, CVD or stroke. Therefore, not removing magnesium from drinking water (eg, by RO) or in certain situations, increasing the magnesium intake from water, may be beneficial, especially for populations with an insufficient dietary intake of the mineral.[50]

On the other hand, the British Regional Heart Study revealed that neither high water hardness nor high calcium nor magnesium intake appreciably protected participants against CHD or CVD.[51] Another study in the Netherlands also found no evidence for an overall significant association between tap-water hardness or magnesium or calcium concentrations and mortality from ischemic heart disease (IHD) or stroke.[52] An inverse or protective association between water hardness and cardiovascular mortality has been reported in most, but not all, previous studies.

No supporting evidence exists concerning a higher rate of renal disease or stone formation with use of water high in

TDS. Water containing excess calcium is tightly regulated by the mechanism of intestinal absorption and elimination, except for those individuals with milk alkali syndrome or hypercalcemia, whereas a higher intake of magnesium is of concern for people with renal insufficiency.[53]

On the contrary, water with a high magnesium level has been found to be associated with a lower incidence of urinary calculus.[54] Further, mineral water with a higher calcium content has been shown to induce higher calcium excretion but significantly decreased oxalate excretion. No definite evidence exists that hard water is more lithogenic than soft water.[55] Epidemiologic evidence has shown that higher calcium intake is associated with lower recurrence rates of calcium-oxalate stones. That result is likely explained by calcium's inhibition of absorption of intestinal oxalate.[56] Consequently, water with a high calcium constituent reduces calcium-oxalate stone formation.

Mineral-water consumption could be a simple and inexpensive approach for osteoporosis prevention and could be of major interest for long-term prevention of bone loss.[30] Mineral waters have a beneficial effect on bone metabolism that has mainly been attributed to their calcium content.[57-59] Calcium-rich mineral waters have been shown to be an alternative to dairy products as the calcium bioavailability is similar or possibly even better.[60] The minerals in alkaline water together with the HCO_3^- also seem to play an important role in decreasing bone resorption and increasing BMD.[61,16]

In a study that included 30 female dieticians aged 26.3 years (SD, 7.3), it was also revealed that alkaline mineral water can significantly reduce bone resorption, whereas acid-rich calcium water had no effect on bone resorption.[62] Wynn et al[63] concluded that the best waters for bone health are rich in both HCO_3^- and Ca, and low in SO_4. Supplementation with electrolyzed, reduced water (ie, alkaline ionized water) might provide an antioxidant defense mechanism in pancreatic beta cells, a finding that was revealed in mice that were experimentally induced with diabetes[64] and that showed an improved blood-glucose control. That result could have occurred due to enhanced insulin sensitivity as well as increased insulin release. Those results suggest that electrolyzed, reduced water may function as an orally effective, antidiabetic agent.

REDUCTION OF ACIDS AND TOXINS PRODUCED BY DIGESTIVE TRACT BACTERIA

Bacterial overgrowth is most prominent in the upper digestive tract (ie, the mouth and pharynx) and in the terminal portion (ie, the large intestine), whereas the middle part (ie, the stomach and small intestine) contains far fewer microbes as the result of highly acidic or highly alkaline media. Therefore, unhealthy teeth or gums and bad oral hygiene may play a significant role in producing an acid load in the blood stream, which is formed by oral and pharyngeal microorganisms. Those changes might be the cause of a relationship between bad oral hygiene and CVD.

The human gut's microorganisms contribute 36% of the small molecules that are found in human blood, and the gut also plays a major role in creating a susceptibility to certain human diseases.[65] The microbial population colonizing the human intestinal tract includes a number of aerobic and anaerobic bacteria that produce one or more toxins. Those toxins have been shown to have the ability to penetrate intestinal cells after their binding to specific surface receptors.[66]

In the absence of respiration or photosynthesis, bacteria are entirely dependent on substrate phosphorylation for their energy. Many compounds can serve as fermentable growth substrates, and many pathways for their fermentation have evolved. For example, glucose fermentation produces either lactic acid or ethanol and carbon dioxide (CO_2). The end product of bacterial fermentation results in acidification of the surrounding medium.[67] Thus, acids and toxins retained in the digestive tract can leak into the surrounding tissues and the blood, affecting the whole body's systems.

A meta-analysis of observational studies revealed that participants with periodontal diseases have higher odds and higher risks of developing CVD.[68] A study including 104 patients of both genders, aged 50 to 90 years, showed a relationship between the bad condition of the oral cavities of the patients and hypertension and, specifically, fresh myocardial infarctions.[69] It has also been found that dental disease is associated with an increased risk of CHD, particularly in young men.[70]

Moreover, bacterial overgrowth with high acid production may result from improperly digested food. That could happen if large food particles arrive in the large intestine of people who have problems with chewing or who insufficiently chew food and/or who eat fast. The digestion in the stomach may also be affected by drinking a large quantity of water during or immediately after a meal, which could result in dilution of stomach acids and enzymes. Overeating after fullness also may surpass the digestive system's abilities, which might lead to the escape of some undigested food into the large intestine. In addition, when an individual eats some food only a short period after eating a main meal, approximately 30 minutes, the stomach is still in the process of evacuating that first entirely digested meal. Eating again could lead to mixing digested and undigested foods, which are then pushed toward the duodenum.

Eating while not hungry or during a satisfaction state may also affect digestion as a result of insufficient production of saliva and/or digestive enzymes. Intended, delayed bowel evacuation or not emptying the bowel before bedtime might play same role in producing high acids and toxins. Therefore, it is advisable to evacuate the bowel as soon as possible after feeling the urge for propulsion.

Fast eating can definitely lead to insufficient food chewing. It has been noticed that a possible relationship exists between faster eating speeds and the increased risk of type 2 diabetes mellitus.[71] Teeth flossing by threads or wooden or plastic sticks, which removes food particles and plaques that breed bacteria, also can reduce acid production in the mouth cavity.

A recent study suggested that flossing and brushing of interdental spaces might reduce the risk for new cardiovascular events among patients with CHD.[72] A cycle could happen in a sequential and cumulative pattern as follows—poor oral hygiene, gum disease, teeth plaques, teeth carries, teeth loss, and, finally, ineffective chewing. In a large cross-sectional study, Holmlund et al[73] reported a relationship between an increased risk in the self-reported history of antihypertensive treatment and the number of diseased periodontal pockets as well as a linear trend between periodontal-disease severity and antihypertension treatment. The presence of periodontal disease has also been found to be associated with metabolic syndrome, suggesting that preventing periodontal disease may prevent metabolic syndrome.[74] In addition, a meta-analysis revealed that periodontal disease appears to be a possible risk factor for pre-eclampsia.[75]

Earthing (Grounding)

Earthing or grounding is connecting the human body to the earth in different ways. It could be performed by walking with bare feet or by connecting the body using an apparatus that provides a conductive system to the earth. The body could be earth-grounded by means of a conductive patch or earthing sleep system on a bed's mattress that is connected to a building's earthing system. It is recommended to connect the body with the earth directly or naturally, away from electrical interference from the building's systems or from electrical stations (ie, by a connection that is free from electric fields).

It has been established that the earth's surface possesses a limitless and continuously renewed supply of free or mobile electrons. The surface of the planet is electrically conductive, except in limited, very dry areas such as deserts, and its negative potential is maintained (ie, its electron supply is replenished) by the global atmospheric electrical circuit.[76,77]

Until a few generations ago, most humans walked and slept in direct contact with the surface of the earth. Our modern lifestyle involves wearing insulating shoes and sleeping in buildings that electrically isolate the body from the ground plane.[78] It has been proposed that free or mobile electrons from the earth could resolve chronic inflammation by serving as natural antioxidants.[79] It is assumed that the influx of free electrons absorbed into the body through direct contact with the earth likely neutralizes free radicals and, thereby, reduces acute and chronic inflammation.[80]

The inflammation theory connects chronic disease with a situation that is describable in electronic or energetic terms. A free radical is a molecule that is missing an electron. Its destructive effects are explained in terms of the rapid and violent reactions taking place as electrical charges are redistributed between the reacting molecules. The violent reactions are the breaking of chemical bonds that are responsible for the integrity of the cell walls of bacteria, cell membranes, DNA, damaged connective tissue, and other structures.[79] The continuous earthing of the human body has revealed a reduction in blood glucose in patients with diabetes, whereas earthing for a single night has been shown to reduce the primary indicators of osteoporosis.[81]

Earthing has been found to increase the zeta potential of red blood cells (RBCs) and to reduce RBC aggregation significantly. The zeta potential is a parameter closely related to the number of negative charges on the surface of an RBC. The higher the number is, the greater is the ability of the RBC to repel other RBCs. Therefore, the greater the zeta potential is, the less coagulable is the blood. Earthing has been shown to increase the surface charge on RBCs and thereby, reduce blood viscosity and clumping.[82,83] It has been concluded that earthing could be one of the simplest, and yet most profound, interventions for helping reduce cardiovascular risk and cardiovascular events.

Earthing also has produced (1) symptomatic improvements in sleep disturbances and chronic muscle and joint pain[84]; (2) the restoration of normal, day-night, cortisol-secretion profiles[85]; (3) a reduction in the electric fields that are induced by AC current on the body[86]; (4) a reduction in overall stress levels and tensions[78]; (5) an increase in parasympathetic-system function and/or a reduction in sympathetic-system function[87]; (6) a speeding of recovery from delayed-onset muscle soreness after exercise[88]; (7) an improvement in heart rate variability[89]; and (8) an improvement in immune response.[88]

In a recent double-blinded study, grounding for 1 hour improved positive moods significantly as compared with the moods of participants who were not grounded.[90] In that study, earthing produced better mood improvement than was experienced through relaxation alone. In cases of experimental injury to the muscles of animals (ie, delayed-onset muscle soreness) grounding reduced pain, altered the numbers of circulating neutrophils and lymphocytes, and also affected various circulating chemical factors related to inflammation.[91] It produced measurable differences in the concentrations of white blood cells, cytokines, and other molecules involved in the inflammatory response. The length of time and degree (ie, the resistance to ground) of grounding is an important factor that can influence the outcomes of inflammation and wound healing.[91] From a historical perspective, American Indians have had a great belief in the healing power of the earth. They have a custom in which they bury sufferers from all kinds of disease in the earth up to their necks, leave them there for some hours, and then remove them. A mud bath is also valuable in obtaining relief from rheumatic pain or pain in the joints caused by injuries, whereas mud packs can also bring down fever and have been shown to be beneficial in the treatment of scarlet fever, measles, and influenza.[92]

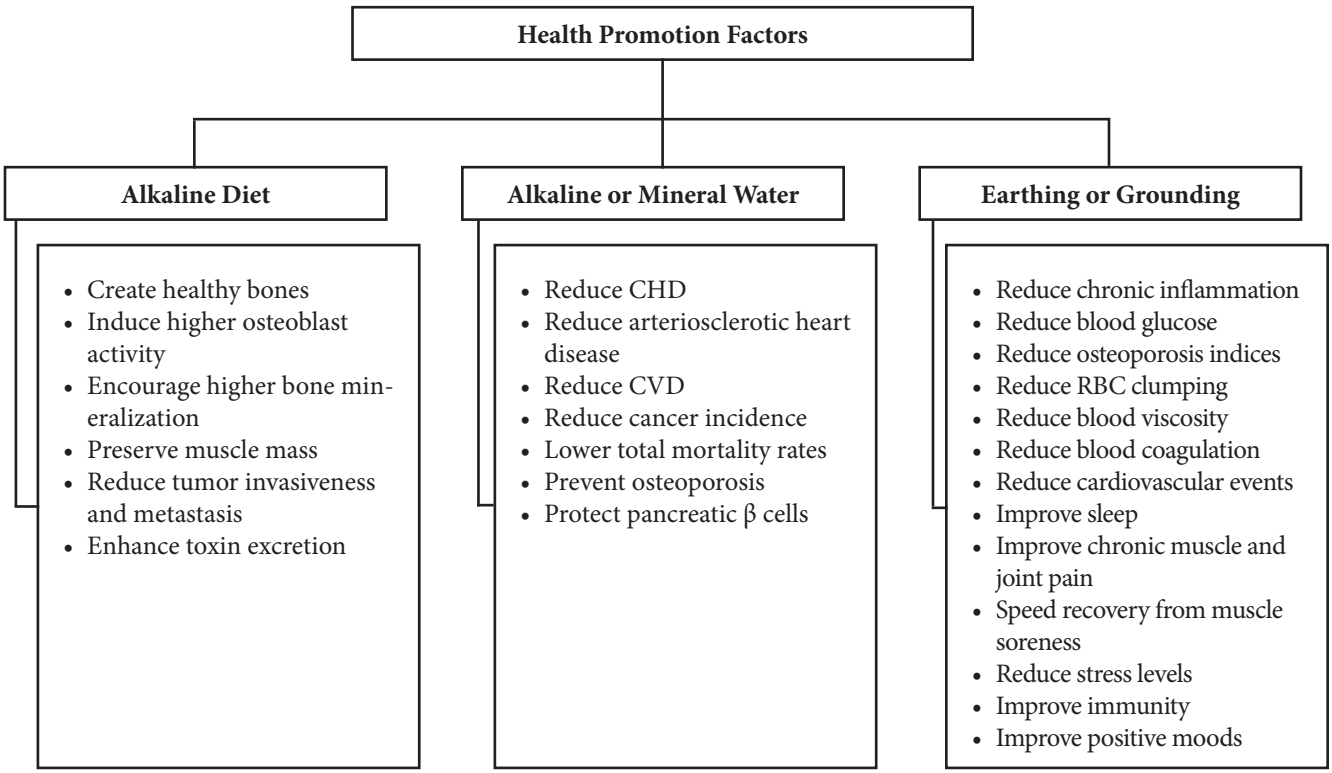
It is now recognized that an overwhelming inflammatory response is the cause of human deaths from infection with the avian H5N1 influenza.[93] In previous studies, earthing has demonstrated its anti-inflammatory effects[80,91] and improvements in the immune response[88] where both effects have been essential for influenza cure. No studies have been found that investigate the effect of earthing in influenza treatment. Future studies are suggested to reveal the effects of grounding for such treatment.

SUMMARY

Supporting evidence exists that an alkaline diet and alkaline water with sufficient protein intake can support bone mineralization, whereas consumption of excess fruits, vegetables, and alkaline water has shown a significant promotion of health, especially for people at an older age (Figure 1, Table 2). With advanced age and reduced renal capacity, the tendency for people to suffer from low-grade acidosis increases, which might explain the rapid, overall health deterioration that comes with greater age. With metabolic acidosis, the body's ability to excrete toxins also declines. To overcome those defects, it is recommended that people consume foods that are higher in alkaline substances and alkaline water as well as avoid an acidic diet and acidic water (ie, water low in minerals) as they grow older.

People in some countries have been collecting rainwater for drinking purposes, and, thereafter, the rainwater is stored in containers that are not tightly closed, which tends to cause it to absorb carbon dioxide from the air. That procedure results in a gradual lowering of the pH due to the formation of a weak carbonic acid. Through that process, the water can get as low as 5.5 on the pH scale, with no minerals, which could have harmful health effects. Through the natural water cycle after rain, water has to be mixed with soil to obtain essential minerals. It is recommended that people drink water from mineral-rich alkaline springs or rivers and avoid RO water. RO water contains an insufficient amount of essential minerals. Water containing high levels of calcium and magnesium is associated with a lower incidence of urinary-tract stone formation.

Figure 1. Natural Factors With Health-enhancement Effects

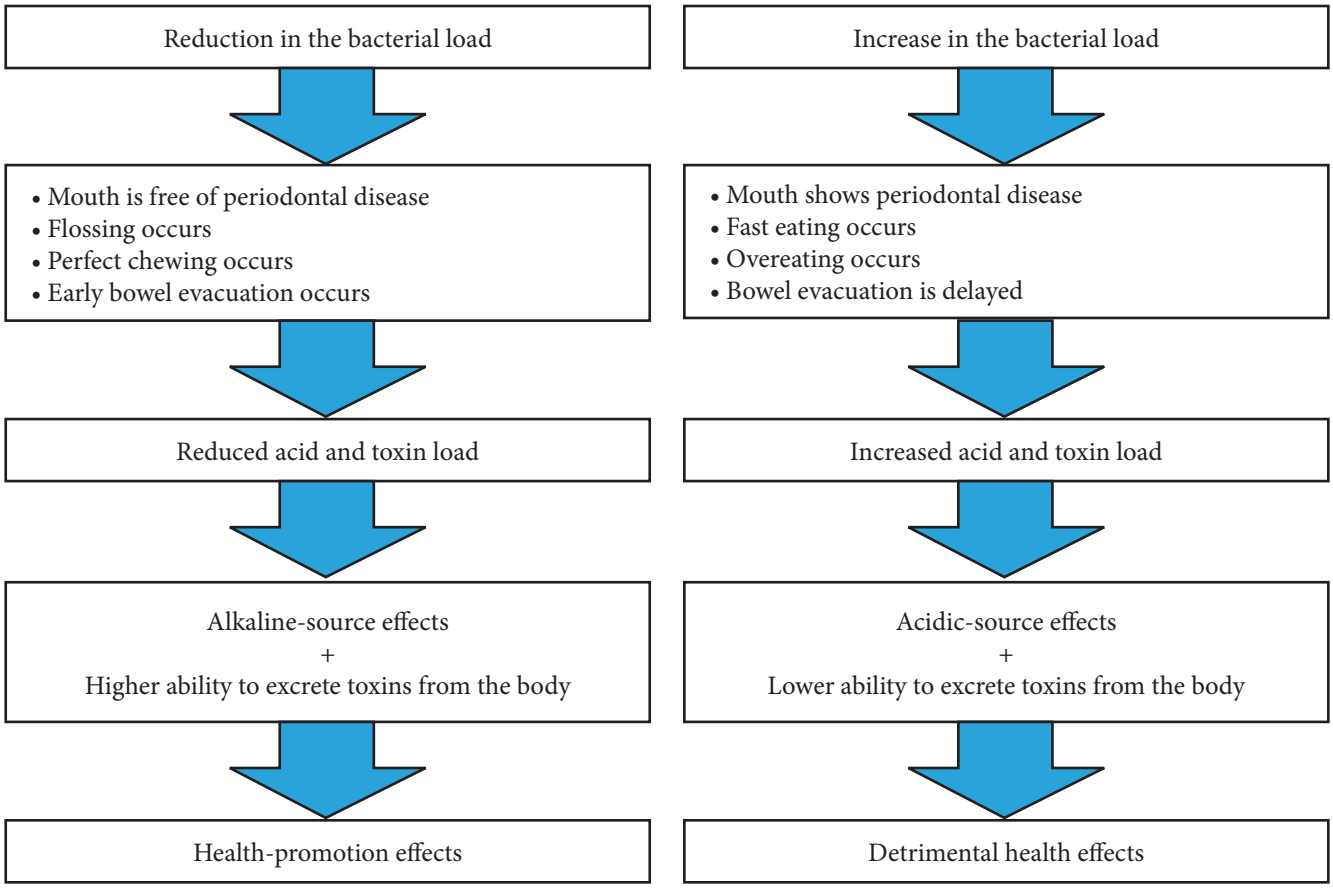


Abbreviations: CHD, coronary heart disease; CVD, cardiovascular disease; RBC, red blood cells.

Table 2. Detrimental Health Effects of an Acidic Diet and Acidic or Low-mineral Water

Acidic Diet	Acidic or Low-mineral Water
Bone resorption[12,13,15,16,19,20,21,22,23,24,25,27,29,30]	Bone resorption[16,30,57,58,59,61,62]
Muscle-mass-preservation defect[29,32,33]	Higher coronary heart disease[41]
Tumor invasion and metastasis[34]	Higher arteriosclerotic heart disease[42]
Ineffective toxin excretion[35]	Higher cardiovascular disease[43,44,47,48,49,50]
	Higher stroke[50]
	Higher cancer[45]
	Higher total mortality[44,46]

Figure 2. The Influence of the Bacterial Load in the Digestive Tract on Overall Health



Flossing teeth after each meal is necessary to reduce bacterial-acid production from the mouth's buccal cavity. Large-bowel emptying should be performed as soon as possible after feeling fullness or any urge for evacuation. Delayed bowel evacuation could result in prolonged body contact, especially during sleep, with acids and toxins, which are byproducts of bacteria. Overeating, fast eating, and imperfect food chewing may produce bacterial overgrowth in the digestive tract, with overproduction of acids and toxins that are absorbed into the bloodstream (Figure 2).

Some studies have indicated that the human body's direct contact with the earth could have several favorable health effects, including anti-inflammatory effects, relief of muscle and joint pain, immunity reinforcement, provision of antioxidants, prevention of bone resorption, blood-glucose reduction in diabetics, anticoagulatory effects, sleep improvement, and positive mood enhancement.

CONCLUSIONS

Favorable health effects could be obtained by consumption alkaline diets, which are rich in fruits and vegetables, and drinking alkaline mineral water. Reduction in the bacterial bulk of the digestive tract could also prevent many chronic degenerative diseases. Earthing or grounding proved to be effective as anti-inflammatory, enhance immunity, improve mood, reduce blood viscosity, and many other beneficial effects.

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REFERENCES

1. Paulev PE, Zubieta-Calleja GR. Essentials in the diagnosis of acid-base disorders and their high altitude application. *J Physiol Pharmacol*. 2005;56(suppl 4):155-170.
2. Gluck SL. Acid-base. *Lancet*. 1998;352(9126):474-479.
3. Frassetto L, Morris RC Jr, Sellmeyer DE, Todd K, Sebastian A. Diet, evolution and aging—the pathophysiologic effects of the post-agricultural inversion of the potassium-to-sodium and base-to-chloride ratios in the human diet. *Eur J Nutr*. 2001;40(5):200-213.
4. Kraut JA, Madias NE. Serum anion gap: Its uses and limitations in clinical medicine. *Clin J Am Soc Nephrol*. 2007;2(1):162-174.
5. Frassetto LA, Morris RC Jr, Sebastian A. Effect of age on blood acid-base composition in adult humans: Role of age-related renal functional decline. *Am J Physiol*. 1996;271(6, pt 2):F1114-F1122.
6. Sebastian A, Frassetto LA, Sellmeyer DE, Merriam RL, Morris RC Jr. Estimation of the net acid load of the diet of ancestral preagricultural Homo sapiens and their hominid ancestors. *Am J Clin Nutr*. 2002;76(6):1308-1316.
7. McSherry E, Morris RC Jr. Attainment and maintenance of normal stature with alkali therapy in infants and children with classic renal tubular acidosis. *J Clin Invest*. 1978;61(2):509-527.
8. Frassetto L, Morris RC Jr, Sebastian A. Potassium bicarbonate reduces urinary nitrogen excretion in postmenopausal women. *J Clin Endocrinol Metab*. 1997;82(1):254-259.
9. Wass JA, Reddy R. Growth hormone and memory. *J Endocrinol*. 2010;207(2):125-126.
10. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: A proposal for reporting: Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *JAMA*. 2000;283(15):2008-2012.

11. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Ann Intern Med*. 2009;151(4):264-269.
12. Remer T, Manz F. Potential renal acid load of foods and its influence on urine pH. *J Am Diet Assoc*. 1995;95(7):791-797.
13. Remer T, Manz F. Estimation of the renal net acid excretion by adults consuming diets containing variable amounts of protein. *Am J Clin Nutr*. 1994;59(6):1356-1361.
14. New SA. Intake of fruit and vegetables: Implications for bone health. *Proc Nutr Soc*. 2003;62(4):889-899.
15. Sebastian A, Harris ST, Ottaway JH, Todd KM, Morris RC Jr. Improved mineral balance and skeletal metabolism in postmenopausal women treated with potassium bicarbonate. *N Engl J Med*. 1994;330(25):1776-1781.
16. Buclin T, Cosma M, Appenzeller M, et al. Diet acids and alkalis influence calcium retention in bone. *Osteoporos Int*. 2001;12(6):493-499.
17. Breslau NA, Brinkley L, Hill KD, Pak CY. Relationship of animal protein-rich diet to kidney stone formation and calcium metabolism. *J Clin Endocrinol Metab*. 1988;66(1):140-146.
18. Shin S, Sung J, Joung H. A fruit, milk and whole grain dietary pattern is positively associated with bone mineral density in Korean healthy adults. *Eur J Clin Nutr*. 2015;69(4):442-448.
19. Barzel US, Massey LK. Excess dietary protein can adversely affect bone. *J Nutr*. 1998;128(6):1051-1053.
20. Bushinsky DA, Frick KK. The effects of acid on bone. *Curr Opin Nephrol Hypertens*. 2000;9(4):369-379.
21. Meghji S, Morrison MS, Henderson B, Arnett TR. pH dependence of bone resorption: Mouse calvarial osteoclasts are activated by acidosis. *Am J Physiol Endocrinol Metab*. 2001;280(1):E112-E119.
22. Tucker KL, Hannan MT, Kiel DP. The acid-base hypothesis: Diet and bone in the Framingham Osteoporosis Study. *Eur J Nutr*. 2001;40(5):231-237.
23. Arnett T. Regulation of bone cell function by acid-base balance. *Proc Nutr Soc*. 2003;62(2):511-520.
24. Brandao-Burch A, Utting JC, Orriss IR, Arnett TR. Acidosis inhibits bone formation by osteoblasts in vitro by preventing mineralization. *Calcif Tissue Int*. 2005;77(3):167-174.
25. Green J, Kleeman CR. Role of bone in regulation of systemic acid-base balance. *Kidney Int*. 1991;39(1):9-26.
26. Arnett TR. Extracellular pH regulates bone cell function. *J Nutr*. 2008;138(2):415S-418S.
27. Krieger NS, Frick KK, Bushinsky DA. Mechanism of acid-induced bone resorption. *Curr Opin Nephrol Hypertens*. 2004;13(4):423-436.
28. Dawson-Hughes B, Harris SS, Palermo NJ, Castaneda-Sceppa C, Rasmussen HM, Dallal GE. Treatment with potassium bicarbonate lowers calcium excretion and bone resorption in older men and women. *J Clin Endocrinol Metab*. 2009;94(1):96-102.
29. Tucker KL, Morita K, Qiao N, Hannan MT, Cupples LA, Kiel DP. Colas, but not other carbonated beverages, are associated with low bone mineral density in older women: The Framingham Osteoporosis Study. *Am J Clin Nutr*. 2006;84(4):936-942.
30. Wynn E, Krieg MA, Lanham-New SA, Burckhardt P. Postgraduate symposium: Positive influence of nutritional alkalinity on bone health. *Proc Nutr Soc*. 2010;69(1):166-173.
31. Hanley DA, Whiting SJ. Does a high dietary acid content cause bone loss, and can bone loss be prevented with an alkaline diet? *J Clin Densitom*. 2013;16(4):420-425.
32. Welch AA, MacGregor AJ, Skinner J, Spector TD, Moayyeri A, Cassidy A. A higher alkaline dietary load is associated with greater indexes of skeletal muscle mass in women. *Osteoporos Int*. 2013;24(6):1899-1908.
33. Dawson-Hughes B, Harris SS, Ceglia L. Alkaline diets favor lean tissue mass in older adults. *Am J Clin Nutr*. 2008;87(3):662-665.
34. Robey IF, Baggett BK, Kirkpatrick ND, et al. Bicarbonate increases tumor pH and inhibits spontaneous metastases. *Cancer Res*. 2009;69(6):2260-2268.
35. Minich DM, Bland JS. Acid-alkaline balance: Role in chronic disease and detoxification. *Altern Ther Health Med*. 2007;13(4):62-65.
36. Doria MF. Bottled water versus tap water: Understanding consumers' preferences. *J Water Health*. 2006;4(2):271-276.
37. World Health Organization. Total dissolved solids in drinking water: Background document for development of WHO Guidelines for drinking-water quality. http://www.who.int/water_sanitation_health/dwq/chemicals/tds.pdf. Accessed March 6, 2016.
38. World Health Organization. *Health Criteria and Other Supporting Information*. Geneva, Switzerland: World Health Organization; 1996.
39. Petraccia L, Liberati G, Masciullo SG, Grassi M, Fraioli A. Water, mineral waters and health. *Clin Nutr*. 2006;25(3):377-385.
40. Burckhardt P. The effect of the alkali load of mineral water on bone metabolism: Interventional studies. *J Nutr*. 2008;138(2):435S-437S.
41. Schroeder HA. Relation between mortality from cardiovascular disease and treated water supplies: Variations in states and 163 largest municipalities of the United States. *J Am Med Assoc*. April 1960;172:1902-1908.
42. Schroeder HA. Municipal drinking water and cardiovascular death rates. *JAMA*. 1966;195(2):81-85.
43. Sauer HI. Relationship between trace element content of drinking water and chronic diseases. In: *Trace Metals in Water Supplies: Occurrence, Significance, and Control*. Urbana, IL: University of Illinois; 1974:39-48.
44. Craun GF, McCabe LJ. Problems associated with metals in drinking water. *J Am Water Works Assoc*. 1975;67(11):593-599.
45. Burton AC, Cornhill JF. Correlation of cancer death rates with altitude and with the quality of water supply of the 100 largest cities in the United States. *J Toxicol Environ Health*. 1977;3(3):465-478.
46. Crawford MD, Gardner MJ, Morris JN. Mortality and hardness of water. *Lancet*. 1968;1(7551):1092.
47. Catling LA, Abubakar I, Lake IR, Swift L, Hunter PR. A systematic review of analytical observational studies investigating the association between cardiovascular disease and drinking water hardness. *J Water Health*. 2008;6(4):433-442.
48. Monarca S, Zerbini I, Simonati C, Gelatti U. Drinking water hardness and chronic degenerative diseases, II: Cardiovascular diseases [in Italian]. *Ann Ig*. 2003;15(1):41-56.
49. Momeni M, Gharedaghi Z, Amin MM, Poursafa P, Mansourian M. Does water hardness have preventive effect on cardiovascular disease? *Int J Prev Med*. 2014;5(2):159-163.
50. Monarca S, Donato F, Zerbini I, Calderon RL, Craun GF. Review of epidemiological studies on drinking water hardness and cardiovascular diseases. *Eur J Cardiovasc Prev Rehabil*. 2006;13(4):495-506.
51. Morris RW, Walker M, Lennon LT, Shaper AG, Whincup PH. Hard drinking water does not protect against cardiovascular disease: New evidence from the British Regional Heart Study. *Eur J Cardiovasc Prev Rehabil*. 2008;15(2):185-189.
52. Leurs LJ, Schouten LJ, Mons MN, Goldbohm RA, van den Brandt PA. Relationship between tap water hardness, magnesium, and calcium concentration and mortality due to ischemic heart disease or stroke in the Netherlands. *Environ Health Perspect*. 2010;118(3):414-420.
53. World Health Organization. Hardness in drinking-water: Background document for development of WHO guidelines for drinking-water quality. http://www.who.int/water_sanitation_health/dwq/chemicals/hardness.pdf. Published 2011. Accessed May 30, 2015.
54. Basiri A, Shakhssalim N, Khoshdel AR, Pakmanesh H, Radfar MH. Drinking water composition and incidence of urinary calculus: Introducing a new index. *Iran J Kidney Dis*. 2011;5(1):15-20.
55. Caudarella R, Rizzoli E, Buffa A, Bottura A, Stefoni S. Comparative study of the influence of 3 types of mineral water in patients with idiopathic calcium lithiasis. *J Urol*. 1998;159(3):658-663.
56. Finkielstein VA, Goldfarb DS. Strategies for preventing calcium oxalate stones. *CMAJ*. 2006;174(10):1407-1409.
57. Meunier PJ, Jenvrin C, Munoz F, de la Gueronnière V, Garnero P, Menz M. Consumption of a high calcium mineral water lowers biochemical indices of bone remodeling in postmenopausal women with low calcium intake. *Osteoporos Int*. 2005;16(10):1203-1209.
58. Heaney RP. Absorbability and utility of calcium in mineral waters. *Am J Clin Nutr*. 2006;84(2):371-374.
59. Costi D, Calcaterra PG, Iori N, Vourna S, Nappi G, Passeri M. Importance of bioavailable calcium drinking water for the maintenance of bone mass in post-menopausal women. *J Endocrinol Invest*. 1999;22(11):852-856.
60. Bohmer H, Müller H, Resch KL. Calcium supplementation with calcium-rich mineral waters: A systematic review and meta-analysis of its bioavailability. *Osteoporos Int*. 2000;11(11):938-943.
61. Roux S, Baudoin C, Boute D, Brazier M, De La Guéronniere V, De Vernejoul MC. Biological effects of drinking-water mineral composition on calcium balance and bone remodeling markers. *J Nutr Health Aging*. 2004;8(5):380-384.
62. Wynn E, Krieg MA, Aeschlimann JM, Burckhardt P. Alkaline mineral water lowers bone resorption even in calcium sufficiency: Alkaline mineral water and bone metabolism. *Bone*. 2009;44(1):120-124.
63. Wynn E, Raetz E, Burckhardt P. The composition of mineral waters sourced from Europe and North America in respect to bone health: Composition of mineral water optimal for bone. *Br J Nutr*. 2009;101(8):1195-1199.
64. Kim MJ, Kim HK. Anti-diabetic effects of electrolyzed reduced water in streptozotocin-induced and genetic diabetic mice. *Life Sci*. 2006;79(24):2288-2292.
65. Hood L. Tackling the microbiome. *Science*. 2012;336(6086):1209.
66. Donelli G, Falzano L, Fabbri A, Fiorentini C, Mastrantonio P. Enteric toxins from bacteria colonizing human gut. *Microb Ecol Health Dis*. 2000;(suppl 2):194-208.
67. Brooks GF, Carroll KC, Butel JS, Morse SA, eds. *Jawetz, Melnick & Adelberg's Medical Microbiology*. New York, NY: McGraw-Hill Companies; 2010.
68. Blaizot A, Vergnes JN, Nuwwareh S, Amar J, Sixou M. Periodontal diseases and cardiovascular events: Meta-analysis of observational studies. *Int Dent J*. 2009;59(4):197-209.
69. Gołębiewska M, Taraszkiewicz-Sulik K, Kuklińska A, Musiał WJ. Periodontal condition in patients with cardiovascular diseases. *Adv Med Sci*. 2006;51(suppl 1):69-72.
70. DeStefano F, Anda RF, Kahn HS, Williamson DF, Russell CM. Dental disease and risk of coronary heart disease and mortality. *BMJ*. 1993;306(6879):688-691.
71. Radzevičienė L, Ostrauskas R. Fast eating and the risk of type 2 diabetes mellitus: A case-control study. *Clin Nutr*. 2013;32(2):232-235.
72. Reichert S, Schlitt A, Beschow V, et al. Use of floss/interdental brushes is associated with lower risk for new cardiovascular events among patients with coronary heart disease. *J Periodontal Res*. 2015;50(2):180-188.
73. Holmlund A, Holm G, Lind L. Severity of periodontal disease and number of remaining teeth are related to the prevalence of myocardial infarction and hypertension in a study based on 4,254 subjects. *J Periodontol*. 2006;77(7):1173-1178.

74. Morita T, Yamazaki Y, Mita A, et al. A cohort study on the association between periodontal disease and the development of metabolic syndrome. *J Periodontol*. 2010;81(4):512-519.
75. Sgolastra F, Petrucci A, Severino M, Gatto R, Monaco A. Relationship between periodontitis and pre-eclampsia: A meta-analysis. *PLoS One*. 2013;8(8):e71387.
76. Williams ER, Heckman SJ. The local diurnal variation of cloud electrification and the global diurnal variation of negative charge on the Earth. *J Geophys Res*. 1993;98(D3):5221-5234.
77. Anisimov SV, Mareev EA, Bakastov SS. On the generation and evolution of aeroelectric structures in the surface layer. *J Geophys Res*. 1999;104(D12):14359-14367.
78. Chevalier G, Mori K, Oschman JL. The effect of earthing (grounding) on human physiology. *Eur Biol Bioelectromagnetics*. 2006;2(1):600-621.
79. Oschman JL. Can electrons act as antioxidants? A review and commentary. *J Altern Complement Med*. 2007;13(9):955-967.
80. Oschman JL. Charge transfer in the living matrix. *J Bodyw Mov Ther*. 2009;13(3):215-228.
81. Sokal K, Sokal P. Earthing the human body influences physiologic processes. *J Altern Complement Med*. 2011;17(4):301-308.
82. Chevalier G, Sinatra ST, Oschman JL, Sokal K, Sokal P. Earthing: Health implications of reconnecting the human body to the Earth's surface electrons. *J Environ Public Health*. 2012;2012:291541.
83. Chevalier G, Sinatra ST, Oschman JL, Delany RM. Earthing (grounding) the human body reduces blood viscosity—a major factor in cardiovascular disease. *J Altern Complement Med*. 2013;19(2):102-110.
84. Ober AC. Grounding the human body to neutralize bioelectrical stress from static electricity and EMFs. *ESD J*. January 2000. http://www.esdjournal.com/articles/cober/ground.htm. Accessed February 18, 2015.
85. Ghaly M, Teplitz D. The biologic effects of grounding the human body during sleep as measured by cortisol levels and subjective reporting of sleep, pain, and stress. *J Altern Complement Med*. 2004;10(5):767-776.
86. Applewhite R. The effectiveness of a conductive patch and a conductive bed pad in reducing induced human body voltage via the application of earth ground. *Eur Biol Bioelectromagnetics*. 2005;1:23-40.
87. Chevalier G. Changes in pulse rate, respiratory rate, blood oxygenation, perfusion index, skin conductance, and their variability induced during and after grounding human subjects for 40 minutes. *J Altern Complement Med*. 2010;16(1):81-87.
88. Brown D, Chevalier G, Hill M. Pilot study on the effect of grounding on delayed-onset muscle soreness. *J Altern Complement Med*. 2010;16(3):265-273.
89. Chevalier G, Sinatra ST. Emotional stress, heart rate variability, grounding, and improved autonomic tone: Clinical applications. *Integr Med Clin J*. 2011;10(3):16-21.
90. Chevalier G. The effect of grounding the human body on mood. *Psychol Rep*. 2015;116(2):534-543.
91. Oschman JL, Chevalier G, Brown R. The effects of grounding (earthing) on inflammation, the immune response, wound healing, and prevention and treatment of chronic inflammatory and autoimmune diseases. *J Inflamm Res*. March 2015;8:83-96.
92. Bakhru HK. Curative powers of earth. In: Bakhru HK. *The Complete Handbook of Nature Cure*. 3rd ed. Mumbai, India: Jaico Publishing House; 2003.
93. Alleva LM, Cai C, Clark IA. Using complementary and alternative medicines to target the host response during severe influenza. *Evid Based Complement Alternat Med*. 2010;7(4):501-510.