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Review Article

Illnesses in technologically advanced societies due to lack of grounding (earthing)


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ABSTRACT

The research on grounding or earthing summarized here is providing valuable clues about why chronic and autoimmune diseases are rampant, simple and reliable help for those with these health issues, and promising paths forward. During the period when this research was getting started, approximately 2000 to the present, scientists from around the world were establishing connections between inflammation and virtually all chronic diseases (Table 1) using the c-reactive protein assay developed by Ridker and his colleagues at Harvard Medical School. This article reviews Earthing, a safe therapy that optimizes (balances) each person's unique physiological functions; and that provides relief from the major diseases of the aging population; and that may slow the aging process itself. This statement is made because of the recognition that cumulative damage by reactive oxygen species (ROS), sometimes referred to as free radicals, is one of the most widely studied theories of the cause of aging. Because the continuous semi-conducting fabric of the body reaches into every part of the body, including the interiors of all cells and their nuclei, mobile electrons in the grounded or earthed person are thought to be capable of rapidly neutralizing ROS produced by oxidative metabolism taking place in every cell and tissue.

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Dedicated to the memory of

Dr. Stephen T. Sinatra, MD, FACC, FACN, CNS

Dr. Sinatra (1946–2022) contributed expertise and enthusiasm that led to some of the major pieces of the research described in this article. Dr. Sinatra was a widely respected and well-known cardiologist whose understandings of inflammation and chronic diseases led to several of the most important studies cited here. Dr. Sinatra graduated from New York's Albany Medical College with an MD in 1972 and was certified in internal medicine in 1975. He became a fellow of the American College of Cardiology in 1977. He held certifications from the Massachusetts Society for Bioenergetic Analysis (1992) and the Certification Board for Nutrition Specialists (2000). He was also certified by the American Board of Anti-Aging Medicine (1998) and was a fellow of the American College of Nutrition. Stephen studied and wrote extensively on coenzyme Q_{10} in the prevention and treatment of heart disease. This led him to develop a new branch of cardiology in the United States: "metabolic cardiology." This field involves preventing and treating cardiovascular disease with nutraceuticals which improve ATP production in heart cells. Dr. Sinatra has lectured about metabolic cardiology and energy medicine, focusing on the use of electroceuticals such as grounding or "earthing" to improve the body's capacity to heal at the cellular level. His input into our research on Earthing has been invaluable, and he will long be remembered and missed by our team of researchers.

Dr. Stephen T. Sinatra

Perspective

The incidence of almost every chronic disease has increased relentlessly in every age group for the past 50 years. Diabetes which was once rare (<0.7% if the population) is now projected to affect 35% of the people in their lifetime [1]. Over the past 50–60 years, the world has seen an unparalleled and unprecedented growth in noncommunicable (chronic) disease [2]. Nearly 30% of the US adult population has multiple chronic conditions [3]. Something profound and very basic is missing in our understandings of nature, physiology, and healthy relations with our environment. The timeline reveals that very serious problems have come upon us relatively recently. In terms of the history of medicine, fifty years is the blink of an eye. Chronic and autoimmune diseases have replaced acute infectious disease and trauma as the dominant influence on healthcare delivery. According to the National Institutes of Health, up to 23.5 million Americans (more than seven percent of the population) suffer from an autoimmune disease – and the prevalence is rising. Autoimmune diseases are a leading cause of death and disability [4]. Some autoimmune diseases are rare, while others, such as Hashimoto's disease, affect many people, particularly women. Clearly, something tragic is going on! The only problem is that nobody knows exactly what is going on. For example, autoimmune diseases are rampant, but we don't know exactly what causes autoimmunity, and we don't have cures for any autoimmune diseases, just various ways of managing the symptoms.

Until now!

Finding the culprits. Down through the ages, one of the goals of medicine has been to solve puzzling and widespread medical issues. Many patients are sick or debilitated because some factor is in excess or missing. As an historical example of a medical mystery solved, consider scurvy. It has been estimated the disease killed more than 2 million sailors between the 16th and 18th centuries [5]. During the 18th century, scurvy killed more British sailors than wartime enemy action, and changed the course of world history. For example, the Royal Navy enlisted 184,899 sailors during the Seven Years' War; 133,708 of these were "missing" or died from disease, and scurvy was the leading culprit [6]. The cause of scurvy was a confusing mystery until 1747, when James Lind demonstrated that the condition could be treated very simply by supplementing the diet with citrus fruit. This was one of the first controlled clinical experiments ever reported in the history of medicine [7]. Prevention of scurvy became easy, and today, rates of scurvy in most of the world are low, thanks to the widespread availability of citrus fruits and other sources of vitamin C.

One of the prominent figures whose research has been central to the theme of this article was Albert Szent-Györgyi, the Hungarian scientist who received the Nobel Prize in 1937 for the synthesis of ascorbic acid (Vitamin C). We will discuss his more recent work on semiconduction in proteins.

Here we report that there is something basic that has the potential to relieve much of the modern chronic disease crisis! I shall suggest that grounding or earthing is poised to be the equivalent of lemons and limes in terms of chronic and autoimmune diseases – a simple solution to a huge and escalating and drastically expensive set of problems. The solution is as close as the earth under our feet! Feedback from around the world has convinced earthing researchers that many people are suffering from a new deficiency disorder that could be termed "electron deficiency" caused by loss of contact with the surface of the Earth, with its abundant mobile electrons, which are nature's original and best antioxidants. In fact, most dietary antioxidants function by delivering electrons that neutralize the ROS causing inflammation. These mobile electrons are required for normal operation of our

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immune systems, and a wide variety of health issues arise when the body becomes deficient in electrons.

Throughout our evolutionary history, humans have walked barefoot on the earth or with leather soled shoes or moccasins that are electrically conductive. And we slept either directly on the earth or on electrically conductive animal hides. With the beginning of the age of plastics, around 1950, we began wearing shoes made of non-conductive materials – plastic, and rubber. In an award-winning film, Clint Ober stated emphatically that insulating shoes were one of the worst inventions ever [Fig. 1A] [8]. In essence, Ober has identified a major culprit in the rise in inflammatory diseases over the past half-century. Fig. 1B shows how the increase in diabetes during the last half century seems to correlate with the sales of athletic shoes with insulating soles. Of course, there are other obvious life-style contributors to inflammatory conditions, including lack of exercise, poor nutrition, smoking, alcoholism, stress, poor sleep, drug side effects, etc.

The relentless increase in the incidence of chronic diseases is well documented. Fig. 2A shows cancer prevalence and projections in the US population from 1975 and predictions to 2040. The projections show what could happen to us in the future without some changes in healthcare practices arising from an increase in awareness of the vital role of occasional skin contact with the surface of the earth [9]. Similar growth in inflammatory conditions is occurring for other chronic issues such as the autoimmune diseases and allergies [Fig. 2B] [10,11].

The pillars of inflammation

Based on visual observations, the ancients characterized acute inflammation by five cardinal signs: redness (rubor), swelling (tumor) heat (calor), pain (dolor) and loss of function (function laesa). These signs were named by the Romans Celsus (30–38 B.C.) and Galen (130–200 A.D.) [12] and can still be found in modern medical texts. However, those who have applied earthing quickly after acute injuries have often noticed that few if any of the so-called cardinal signs materialize. See, for example, Fig. 3. Remarkable as it may seem, there is a growing appreciation among some clinicians and earthing researchers for the idea that the classic signs of inflammation, that trauma or emergency doctors see every day, may actually be artifacts of injury produced when there is inflammation without grounding. On the basis of the research described here we believe it would be beneficial for those who respond to traumatic accidents or to severe cardiovascular issues apply Earthing to their patients as soon as practicable, and, if possible, provide continuous grounding during recovery. Note that modern hospital rooms have electrical outlets with good ground connections.

One of the five pillars of inflammation, heat (calor) is readily observable and quantifiable using medical infrared imaging. Fig. 4 provides an example. The medical infrared images are from a 33-year-old woman who had a gymnastics injury at the age of 15. She had an 18-year history of chronic right knee pain, swelling, and instability, and walking with a cane. She was surprised that after only 30 min of earthing there was a significant reduction in pain and inflammation.

The top row of images in Fig. 4A was taken in the walking position to show the inner aspect of both knees. The arrow points to the exact location of the patient's pain and shows significant inflammation (the reddish color). The lower images were taken after 30 min of exposure to clinical earthing using an earthing patch system, shown in Fig. 4B. Note significant reduction of inflammation in the knee area. After 6 days of clinical earthing (30 min per day), the patient reported a 50% reduction in pain. After 4 weeks of treatment, patient was able to play soccer, and by 12 weeks she went waterskiing. Obviously, the effects of Earthing can take place quickly and are often permanent! This is one of 20 case studies done by Dr.

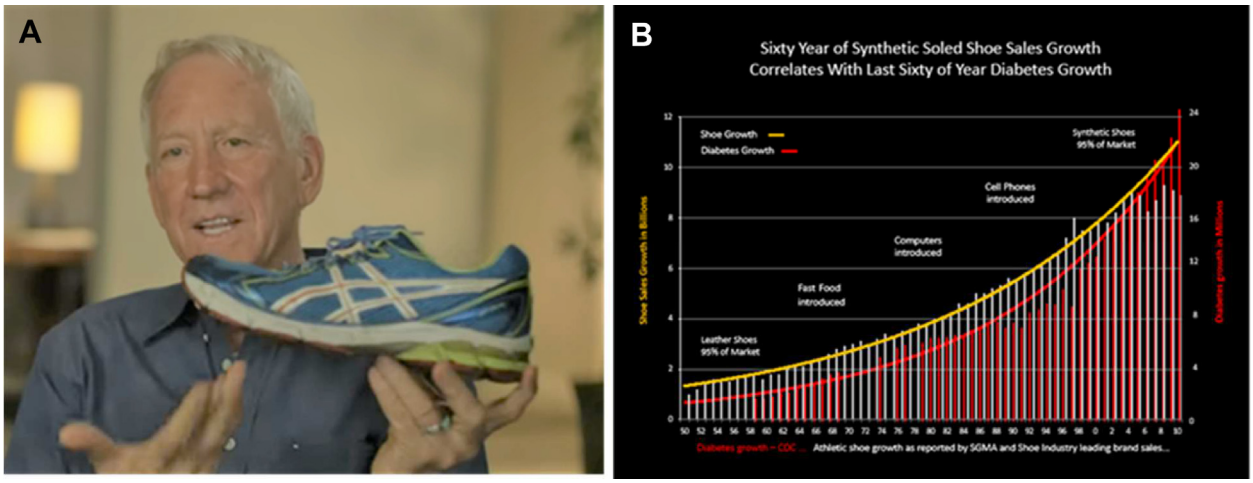

Fig. 1 (A) In The Earthing Movie [7] Clint Ober states, with excellent reasons, that this is the most destructive invention man has ever made. (B) Similarity between growth curve in the incidence of type 2 diabetes and sales of synthetic-sole shoes in the US since the 1950's. In 1950, 95% of shoes were made with leather soles, most of which were electrically conductive. Currently, 95% of shoes have synthetic, nonconductive soles. A similar growth pattern describes the incidence of other chronic diseases that may also be associated with insulating shoe designs and other lifestyle issues. An apparent correlation such as this is obviously suggestive but not proof of causation.

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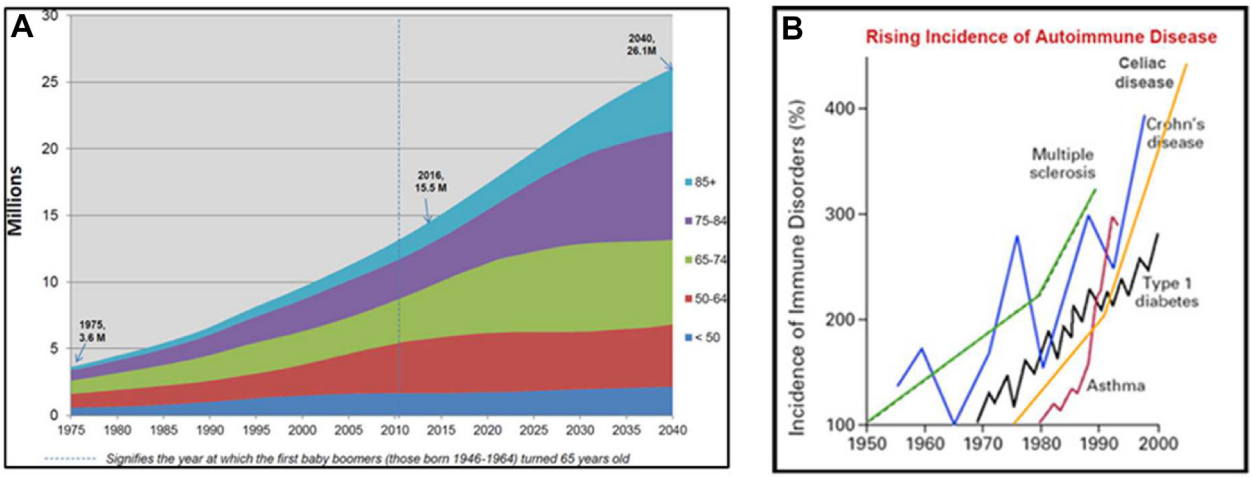

Fig. 2 (A) The relentless increase in the incidence of cancer during the period 1975–2040. The projections show what could happen in the future without some changes in healthcare practices arising from an increase in our understandings of the disease [8]. From Bluethmann SM, Mariotto AB, Rowland JH. Anticipating the "Silver Tsunami": Prevalence and trajectories and comorbidity burden among older cancer survivors in the United States. Cancer Epidemiol Biomarkers Prev. 2016:25:1029–1036. Reproduced by permission of American Association for Cancer Research. (B) Incidence of asthma, type 1 diabetes, multiple sclerosis, Chron's disease, celiac disease and other autoimmune diseases have tripled or quadrupled in recent times [9]. Illustration is from New England Journal of Medicine, Jean François Bach, Review Article, Mechanisms of Disease, The Effect of Infections on Susceptibility to Autoimmune and Allergic Disease, Volume 347, No. 12, pages 911–920, Copyright © 2002, Massachusetts Medical Society. Reproduced by permission of The New England Journal of Medicine/Massachusetts Medical Society.

William Amalu, President of the International Academy of Clinical Thermography [13].

Electrons from the earth can quickly quench the fires of inflammation regardless of their location. There are several reasons earthing works so quickly on inflammation anywhere in the body. First, the body is electrically conductive through a continuous system of "biological wires" composed of semiconductor proteins [14]. This seminal report by Douglas E Friesen, Travis JA Craddock, Aarat P. Kalra, and Jack A Tuszynski lists 16 different "message passing systems" that an organism can utilize for coordinating and energizing various processes in the body. The article includes a fascinating table listing examples of the estimated times for specific message carriers to travel 1 m: diffusion of proteins (317 years); proton diffusion in carbon nanotubes (1.9 years); calcium waves in astrocytes (20 h); electrostatically guided proteins in the cytoskeleton (1.4 h); hormones in arterial blood flow (2.5 s); cardiac impulses (2.3 s); action potentials – unmyelinated nerves (1 s); myelinated nerves (10–18 ms); mechanical stress waves along tensed cytoskeletal filaments (33 ms); proton jump conduction (10 ns); semiconduction of electrons (10 ns); and photons (10 ns). For more detail, see Ref. [14].

Semiconduction of electrons through biopolymers are among the fastest, with an estimated velocity of ~10^8 m/s [15]. In principle, this means that an electron could move from the Earth to the bottoms of one's bare feet and thence to any injured or inflamed tissue or damaged cell anywhere in the body virtually instantaneously. The continuous system of "biological wires" has been called "the living matrix" and it extends through all the connective tissue systems and layers of fascia and across the surfaces of all cells in the body by a system of trans-membrane proteins called integrins. The crucial piece of evidence that gave rise to the living matrix concept was the discovery that the molecular fabrics within all cells, the cytoskeletons, are mechanically and energetically connected across cell surfaces to the surrounding extracellular connective tissue system. The scientist who first described trans-membrane proteins, in 1975 [16] was Mark Bretscher, FRS, at the Medical Research Council Laboratory of Molecular Biology in Cambridge, United Kingdom. He is rarely quoted in the context of integrins. Twenty-two years after Bretscher's discovery, in 1997, Alan F. Horwitz published a review entitled, "Integrins and health. Discovered only recently, these adhesive cell surface molecules have quickly revealed themselves to be critical to proper functioning of the body and to life itself" [17]. A search for "integrins" in PubMed yields 78,185 results (as of 8/6/2022). Thousands of studies over the last several decades have shown that integrins have vital functions in virtually all multicellular animals. The integrins link all of the connective tissues and fascial systems to the cytoskeletons, and the cytoskeletons connect to the nuclear matrices via specific proteins called SUN and CASH [18–20].

Semiconduction in proteins was first suggested by Nobel Laureate Albert Szent-Györgyi in 1940, in an historic presentation, the Korányi Memorial Lecture in Budapest, Hungary. His talk was published in both Science ("Towards a New Biochemistry?") [21] and Nature ("The Study of Energy Levels in Biochemistry") [22] in 1941. With only a few exceptions, this

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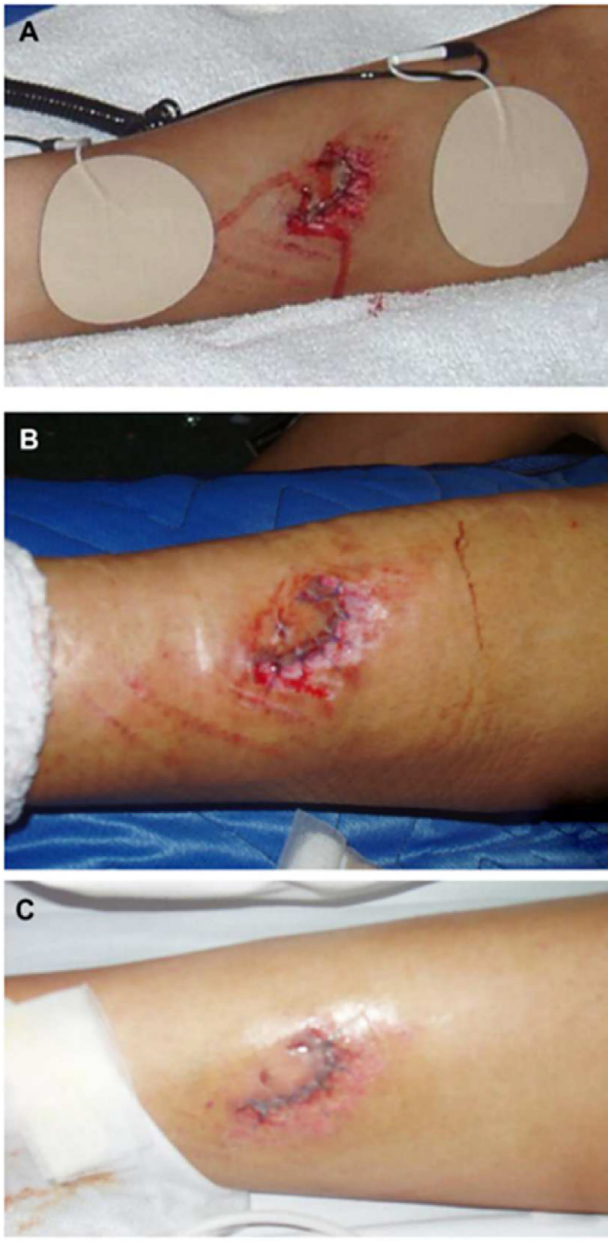

Fig. 3 Rapid recovery from a serious wound with minimal swelling and redness expected for such a serious injury. Notes: Cyclist was injured in Tour de France competition – chain wheel gouged his leg. (A) Grounding patches were placed above and below wound as soon as possible after injury. (B) Day 1 after injury. (C) Day 2 after injury. There was minimal redness, pain, and swelling, and cyclist was able to continue the race on the day following the injury. Photos courtesy of Dr Jeff Spencer.

seminal work received little attention from the biomedical community until the valuable report of Friesen and colleagues on biological wires, published in 2015 [14]. Further work of Gascoyne, Pethig and Szent-Györgyi in the 1980's [23], now takes a key place in our evolving understanding of inflammation. For Albert Szent-Györgyi's pivotal concept of semiconduction in proteins helps us understand how electrons from the Earth can be semiconducted throughout the body to quickly neutralize inflammation, including silent or smoldering inflammation (terms introduced by inflammation researchers), wherever they might occur, and thereby stop the processes that are thought to lead to chronic inflammation, chronic diseases, and autoimmune disease.

Electron flows from the skin surface to a site of injury or inflammation will follow the usual rules for electron flows in multi-component systems: the preferred route will be the pathway or pathways of least electrical resistance and the gradients in charge density. Moreover, such charge transfers will be driven by the established principles of attraction between opposite charges. However, there is a fascinating and unexpected paradox in the relationship between the speed of electron transfer reactions and the ''driving force.'' Rudolph A. Marcus of the California Institute of Technology predicted a phenomenon that was completely unexpected by chemists' intuition and that was initially difficult to accept and confirm. When the driving force increases beyond a certain level, electron transfer will begin to slow down instead of speed up, as one might expect.

Odd as this may seem, the phenomenon was established experimentally and led to Marcus receiving the Nobel Prize in chemistry in 1992 for his contributions to the theory of electron transfer reactions in chemical systems [24]. A consequence is that an electron transfer process does not necessarily require a large potential gradient and may actually be faster when the potential difference is small.

This fast and natural means of resolving inflammation anywhere in the body occurs when various white blood cells and the toxic ROS they secrete are confined to a site of injury and the positively charged ROS are neutralized by electrons before they can spill into nearby healthy tissues. In other words, optimal healing takes place when there is little or no "collateral damage" to healthy tissue from ROS leaking into the undamaged areas around an injury. Reducing collateral damage is thought to deter the formation of the so-called "inflammatory barricade" which otherwise hinders the entry of circulating antioxidants and repair and regenerative cells into the repair field. Inflammatory barricades around sites of injury are thought to contribute to a vicious cycle in which the immune system continues to send various white blood cells in unsuccessful attempts to finish the cleanup and repair process. It is also thought that it is this lingering "vicious cycle" that eventually leads to chronic inflammation, which then can lead to chronic or autoimmune diseases [25].

Discussion

This article commemorates the convergence of the work of Clinton Ober, Albert Szent-Györgyi, Paul Ridker, and their colleagues, in leading us to a better understanding of chronic and auto-immune disorders that affect millions of people around the world.

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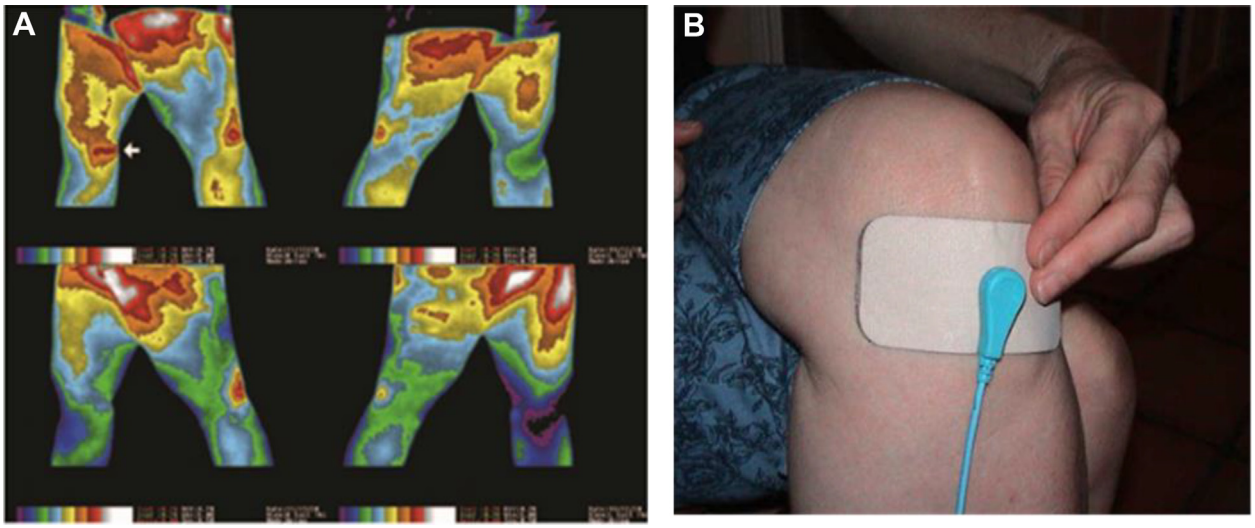

Fig. 4 (A) Medical infrared imaging results with a 33-year-old woman who had a gymnastics injury at the age of 15. She had an 18-year history of chronic right knee pain, swelling, and instability. Top row of images taken in walking position to show inside of both knees. Arrow points to exact location of patient's pain and shows significant inflammation. Lower medical infrared images were taken after 30 min of exposure to clinical earthing using patch system such as the one shown to the right. Note significant reduction of inflammation in knee area. After 6 days of clinical earthing, patient reported a 50% reduction in pain. After 4 weeks of treatment, patient was able to play soccer, and by 12 weeks she went waterskiing. This is one of 20 case studies showing rapid recovery from old injuries tracked with medical infrared imaging. The studies were done by Dr. William Amalu, President of the International Academy of Clinical Thermography [12]. (B) Grounding or earthing patch on the knee.

Sometimes scientific discoveries from very different sources converge to reveal something new and unexpected that can lead to dramatic advances in medicine and health. "Using a holistic approach with shared goals, convergence seeks to transcend existing human limitations to achieve improved conditions for work, learning, aging, physical and cognitive wellness" [26]. This article summarizes the remarkable story of such a convergence. The narrative concerns three pioneers from completely different backgrounds. Taken together, the discoveries made by these individuals and their colleagues have profound implications for the health and wellness of everyone. Clint Ober [Fig. 1A] and more than two dozen colleagues and completely independent investigators from around the world (supplemental file 1) documented the fact that earthing or grounding the human body is valuable in the prevention or treatment of a wide range of inflammatory conditions, including the autoimmune disorders. One of the first reports of this work was published by Ober in the year 2000 [27]. In the same year, Paul Ridker MD and his colleagues at Harvard Medical School reported the development of a sensitive test for inflammation called hs-CRP that enabled researchers around the world to study the relationships between chronic inflammation and virtually all chronic diseases [28]. While each of these discoveries is profound, taken together they help explain both the cause and prevention of the chronic and autoimmune disease crisis outlined at the beginning of this article. The discoveries of Ober and his colleagues are clearly documented in an award-winning full-length feature film[1] and in an award-winning book.[2] The work of Ridker and colleagues is documented in major publications in leading medical journals [28]. The third piece of the puzzle came from the work of Nobel Laureate Albert Szent-Györgyi and his colleagues who documented the semiconducting nature of the protein fabric of the body. Hence this article commemorates the convergence of the work of Clinton Ober, Albert Szent-Györgyi, Paul Ridker, and their colleagues, in leading us to a better understanding of

[1] Watch *"The Earthing Movie: The Remarkable Science of Grounding,"* the winner of the Audience Award for Best Documentary at the Los Angeles Dances with Films Festival. The film was directed by Sundance Award-Winning filmmakers Josh and Rebecca Tickell (The Big Fix, FUEL, etc.). The film shares the Tickell family's journey with the healing power of grounding, aka earthing, and the people they met and learned from along the way; featuring grounding pioneer Clint Ober, author Deepak Chopra M.D., actress/activists Amy Smart, and Mariel Hemingway, cardiologist Dr. Stephen Sinatra, renowned advocate of alternative medicine Dr Joseph Mercola, engineer, physicist Gaétan Chevalier PhD, biophysicist James Oschman PhD., and many others. https://www.youtube.com/watch?v=44ddtR0XDVU&t=1s.

[2] Earthing: The Most Important Health Discovery Ever! (Second Edition) by Ober, Sinatra and Zucker, [63] winner of the 2011 Nautilus Award in Wellness/Prevention/Health & Healing. The Nautilus Awards recognize books that promote spiritual growth, conscious living, and positive social change, while at the same time stimulating the "imagination" and offering the reader "new possibilities" for a better life and a better world.

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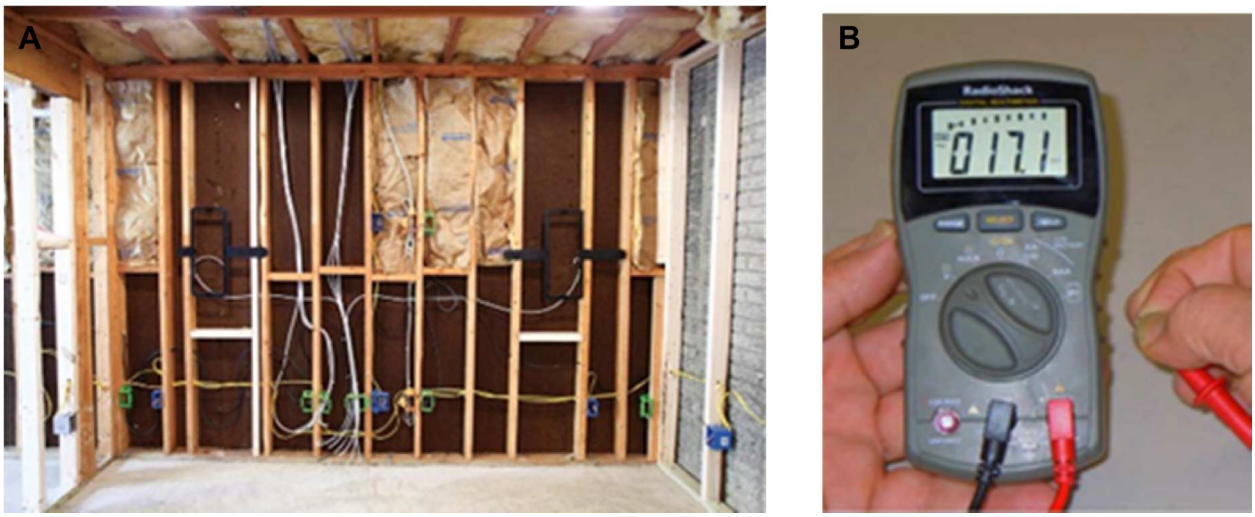

Fig. 5 (A) Wiring behind the unfinished wall of a bedroom. (B) The AC (alternating current) voltage on a person's body can be measured with a voltmeter [64]. The black terminal is connected with a wire to a rod in the ground and the red terminal connects to a probe held in the right hand. Here a voltage of 17.1 V is measured on a person's body. Experience and research have shown that this level of voltage is not conducive to relaxation and sleep and can be associated with a number of chronic disorders listed in supplemental file 2.

chronic and auto-immune disorders that affect millions of people around the world.

> Many medical researchers are now recognizing that inflammation is associated with virtually all major and minor health issues, including all of the diseases of aging. This article commemorates the convergence of the work of Clinton Ober, Albert Szent-Györgyi, Paul Ridker, and their colleagues, in leading us to a better understanding of chronic and auto-immune disorders that affect millions of people around the world.

One of Ober's early observations was that bedrooms often have a high level of 60 Hz electric fields radiating from home wiring concealed behind the walls [Fig. 5A] and from power cords to appliances such as clock radios, heating pads, electric blankets, and bed lamps. These power cords radiate 60 Hz fields even when the appliances are turned off. These fields induce measurable electrical fields on and within the body of a person. These fields can interfere with sleep and with electrical and with biochemical processes within the body, most of which involve electron transfers [29]. These electrical fields can be measured on the body with a simple voltmeter as shown in Fig. 5B. Research done by others has documented how fields from household electricity can interfere with sleep and cause many other health issues (supplemental file 2).

After retirement from the cable industry, Ober made a profound discovery that has benefited many people around the world. The resulting health revolution began with a simple personal observation. When he discovered a strong electric field in his bedroom using a voltmeter such as shown in Fig. 5B, he tried grounding his body with a piece of conductive material connected to a wire that went out his bedroom window to metal post he had pushed into the ground. After lying down and noting that the voltage on his body had decreased dramatically, almost to zero, the next thing he knew it was the next morning. He had fallen asleep quickly and slept soundly without taking the usual pain medications. This was most unusual for him, and he thought deeply about the experience. Putting 2 and 2 together, Ober realized that the reason people do not sleep well is because of pain; pain is caused by inflammation; and grounding his body must have somehow reduced the inflammation and lingering pain he had as a consequence of various surgeries. He became determined to find out why this happened. He went to the library at the University of California in Los Angeles (UCLA) and found no literature on the possible health effects of grounding. Nor could he find any UCLA scientists interested in researching the topic. Ober's determination to find out precisely how earthing was producing such dramatic results led to literature that can now be found in a variety of books and journals in every library in the world.

Eventually Ober's original discovery about the benefits of grounded sleep was followed by a formal study, "The Biologic Effects of Grounding the Human Body During Sleep as Measured by Cortisol Levels and Subjective Reporting of Sleep, Pain, and Stress" by Maurice Ghaly MD and Dale Teplitz, published in 2004 [30]. Cortisol is regarded as "the stress hormone." The subjects were chosen because they had complaints of sleep dysfunction, pain, and stress. Saliva tests were administered at 4-h intervals to establish circadian cortisol profiles. They were then grounded to earth during sleep for 8 weeks in their own beds using conductive mattress pads. At the end of 8 weeks, subjects' 24-h circadian cortisol profiles showed a trend toward normalization, meaning that those with elevated cortisol and those with reduced cortisol had more normal profiles after grounding. Subjectively reported symptoms, including sleep dysfunction, pain, and stress, were reduced or eliminated in nearly all subjects. Again, research by others had already shown that exposure to 60 or 50 cycle

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powerline electric fields is associated with a number of conditions listed in supplemental file 2.

Ober's determination to find out precisely how earthing was producing such dramatic results has led to literature that can now be found in a variety of journals in every library in the world.

The important study by Ghaly and Teplitz [30] associated earthing with improved sleep and with effects on circadian cortisol rhythms. Effects on the endocrine system were confirmed independently by physicians in Poland, Karol and Pawel Sokal. They found interesting effects of earthing on blood chemistry during sleep. Of particular importance to diabetics was their finding that continuous earthing of diabetic patients decreases blood glucose [31].

Of particular importance to diabetics was the finding by two pioneering physicians in Poland, Karol Sokal MD PhD and Pawel Sokal MD PhD that continuous earthing of diabetic patients decreases blood glucose.

And Ober sponsored a follow-up study in 2006 that confirmed reductions in overall stress levels and tensions documented by muscle relaxation and a shift in autonomic balance from stressful sympathetic activation to a calming parasympathetic state upon earthing [32].

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Ober recognized the physiological benefits of connecting ourselves to the electrical "ground plane" at the surface of the earth and developed methods to facilitate such connections to persons inside of a building. In electrical engineering, a ground plane is the name given to an electrically conductive surface, a reference point in an electronic circuit or appliance, usually connected to the earth's surface. In terms of physiology and biochemistry, the proper functioning of living systems involves electrical fields and biochemistry involves the movement of electrons. In fact, one text of organic chemistry shows virtually all of the biochemical reactions as involving flows of electrons [29]. Connecting to the earth stabilizes the body's internal electrical environment in the presence of fields in the external environment.

Everything [in the human body] is electric. This seemingly simple observation has transformational repercussions on the way we think about and approach physical, mental, and emotional health.

~ McKusic (2021) [33].

The electrical circuits in modern homes have a grounding system directly connected to a metal rod driven into the earth. This means that every room in a modern dwelling has a readily available connection to the earth. Electrical outlets in hospital rooms are also well grounded. These grounding terminals are especially important for those suffering from a chronic disease, autoimmune disorder, physical trauma, or chronic pain, as they will likely benefit from having their bodies connected to the earth throughout the day and night. Mr. Ober has developed systems that can deliver the benefits of earthing to the bed, the office, a comfortable chair, in a vehicle, and to a cushion for pets [Fig. 6] [34].

Ober sponsored research showing that grounding the body (earthing) has rapid and beneficial effects on a wide range of physiological measures. Corresponding to each of these measurable benefits was feedback[3] from thousands of earthing enthusiasts around the world confirming many practical wellness advantages from the practice of touching the earth, either by walking barefoot or by using a system that connects a person or pet to the earth while they are inside of a dwelling [35] (supplemental file 3). The best explanation for the results is that an earth connection helps resolve inflammation. The simplest and clearest demonstration was from the medical infrared imaging which shows fading of the "hot spots" caused by inflammation, as shown above in Fig. 4.

During the same time when Ober and associates were studying earthing (approximately the year 2000 to the present), Paul Ridker MD MPH and his colleagues at Harvard Medical School were developing and testing a sensitive test for inflammation called hs-CRP. A significant turning point was a study of 28,263 apparently healthy postmenopausal women over three years, assessing the risk of cardiovascular events associated with base-line levels of various markers of inflammation [28]. Of 12 markers studied, hs-CRP was the strongest predictor of the risk of cardiovascular events. These studies continued for over several decades. By 2021, it could be independently stated that high sensitivity C-reactive protein (hs-CRP) "is a well-established marker of cardiovascular (CV) disease" [36]. Moreover, Ridker and his colleagues recognized the possibility of silent or smoldering inflammation that can be difficult to locate but that can eventually lead to chronic health issues.

The inflammation connection with chronic ailments of all kinds also explained how Earthing or grounding could have such an incredibly wide range of wellness benefits.

[3] Note that we distinguish feedback from testimonials. Some states in the USA do not allow testimonials because one can always find or pay someone to make an enthusiastic comment about a product. A substantial amount feedback on Earthing has been unsolicited and spontaneous, and one of the most common statements has been, "thank you for giving my life back" because Earthing has resolved a miserable and lingering health condition.

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Fig. 6 For the person with a chronic issue or for prevention it can be desirable to maintain grounding throughout the day and night. Various technologies enable this during sleep (A), in the office (B), with a conductive strap (C), with footwear (D) in an automobile (E), and a pet (F). The grounding Auto Seat Mat (E) connects you to the metal frame of your vehicle through an Auto Coil Cord. While this does not create a true earth ground, it pulls harmful static electricity from your body that accumulates as you drive. Indoor pets are also drawn to earthing systems (F).

CRP refers to C-reactive protein, a substance manufactured primarily in the liver and by smooth muscle cells, macrophages, endothelial cells, lymphocytes, and adipocytes when there is inflammation or infection [37]. When cells or tissues are injured and become inflamed, various factors are released that trigger the liver to synthesize and release C-reactive protein (CRP) into your bloodstream. C-reactive protein (CRP) is referred to as an acute inflammatory protein that increases up to 1000-fold at sites of infection or inflammation [37]. CRP binds to factors on the surfaces of dead or dying cells and some bacteria. CRP attracts white blood cells (macrophages) that engulf cellular debris, bacteria and other microbes and that secrete ROS.

The sensitive hs-CRP test was a huge milestone in clinical medicine because it enabled researchers from around the world to determine that many of the most troubling and painful and costly of the modern chronic diseases are correlated with inflammation. A consequence of this research was that Ridker became one of the most frequently cited clinical researchers in the world. The inflammation connection with chronic ailments of all kinds also explained how Earthing or grounding could have such an incredibly wide range of wellness benefits. Note that many medical researchers are now recognizing that inflammation is associated with virtually all major and minor health issues, including all diseases of aging.

Earthing is continuously being associated with relief from more and more conditions. It makes sense that longevity will be enhanced in individuals who practice earthing and benefit from improved sleep, lower stress, and protection from chronic ailments. Moreover, the most widely studied explanation for the aging process is that aging arises from cumulative damage to cells and tissues caused by ROS produced during oxidative metabolism taking place in mitochondria [38]. The semiconducting living matrix can deliver antioxidant electrons to both the mitochondrial matrix and the nuclear matrix, thereby protecting mitochondria from "self-destruction" by ROS produced by oxidative metabolism, and by protecting DNA from oxidative damage. Earthing researchers Martin Zucker and Gaétan Chevalier have written engaging essays on earthing and longevity [39,40].

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After his initial observations of how grounding the body improved his own sleep, Ober and his colleagues began careful research on the effects of earthing on a variety of physiological parameters. The best explanation for the results is that grounding or earthing allows mobile electrons from the earth to enter our bodies and neutralize painful inflammation associated with chronic diseases of all kinds, wherever they may be located. The documented benefits:

- Improved sleep [30]. According to the US Center for Disease Control (CDC) and the American Sleep Association 50–70 million US adults have difficulty sleeping, and drowsy driving is responsible for 1550 fatalities and 40,000 nonfatal injuries annually in the United States [41]. And the nighttime rhythm of cortisol, the "stress hormone" normalizes. One doctor who has been recommending Earthing to his patients for 10 years said this: "The first feedback I usually hear from a patient who just started earthing is, 'best sleep I've had in years.'"
- Pain reduction from virtually all causes [42–44].
- Reduced acute or chronic inflammation [45].
- Relaxation [46]. The autonomic nervous system shifts from sympathetic activation to parasympathetic.
- Accelerated healing of injuries [42–44].
- Increased heart rate variability, a measure of the health of the cardiovascular system [45].
- Reduced blood viscosity [47]. Extensive research has shown that virtually all of the cardiovascular diseases, the number one killer worldwide, are related to elevated blood viscosity. Some cardiologists view blood viscosity as the key to longevity.
- Lowered blood viscosity improves blood flow [44] to nourish your entire body with vital oxygen and nutrition and facilitate elimination of metabolic wastes.
- Improves vitality. Subjects in the studies measurably looked and felt better [48,49].
- Reduces hormonal and menstrual symptoms.
- Reduces muscle tension and headaches.
- Accelerates healing from trauma, injuries, and sports/exercise activity [42,43].
- Protects the body against possibly health-disturbing electromagnetic fields (EMFs) [27,50]. AC body voltage was reduced by an average of 58-fold when participants were grounded compared with when they were not grounded. Normal levels of electromagnetic fields existing in a home or office are too low to produce harmful currents in a grounded person [50].
- Improves blood pressure in hypertensive patients [51].
- Premature babies. Earthing is safe and beneficial for premature infants by improving the resilience of fragile premature babies in incubators surrounded by electromagnetic fields from life-support systems [52].
- Alzheimer's Disease. From Taiwan: Grounding can improve sleep quality among patients with mild Alzheimer's Disease [53].
- Protecting therapists. Hands-on therapists of all kinds can benefit from having their patient grounded [54–57].

The evolution of our new understanding of inflammation that followed from the Harvard study (Ridker and colleagues) can be traced with reference to the database of the US National Library of Medicine, called PubMed [58]. The database comprises more than 34 million citations of biomedical literature from MEDLINE, life science journals, and online books. After Ridker's group published their landmark paper in 2000 there was a huge increase in published studies showing the relationships between inflammation and various diseases. A current listing of these conditions is shown in Table 1. This research helps explain how an anti-inflammatory method such as Earthing or grounding can benefit patients with such a wide range of conditions, and, in the process, enhance longevity.

Table 1 PubMed listings for Inflammation + (As of 8/23/2022).

- Aging: 24,084
- Alzheimer's disease: 10,039
- Arthritis 41,111
- Asthma: 28,461
- Atherosclerosis: 25,708
- Bowel disorders: 44,995
- Cancer: 104,666
- Cirrhosis of the liver: 15,170
- Cystic fibrosis: 4714
- Diabetes: 49,299
- Meningitis: 7648
- Multiple sclerosis: 9718
- Osteoporosis: 3042
- Prostate cancer: 3232
- Psoriasis: 6774
- Rheumatoid arthritis: 21,093

Additionally, based on our observations that Earthing is very effective against respiratory ailments such as asthma and Chronic Obstructive Pulmonary Disease (COPD), we suggested that the cytokine storm and pneumonia that are so deadly from COVID-19 infections might be relieved or prevented simply by placing grounding patches over each lung, with the wires plugged into the ground port of the electrical system [Fig. 7]. We published this suggestion on 03 August 2020 [59]. While our suggestion was a speculation, a few months later, in December 2020, Professor Haider Abdul-Lateef Mousa from the University of Basrah, College of Medicine, Iraq published a paper documenting that Earthing could prevent and treat serious Covid-19 infections [60]. He studied 59 cases of COVID-19 infection using Earthing from 15 min to 3 h/day. He gave an example of a spectacular response in a severely ill patient who was unable to speak due to dyspnea (difficult or labored breathing) with blood oxygen level 38% on continuous oxygen supply. On the second day of 3 h daily earthing, his oxygen level raised to 95% with oxygen supply and 77% without oxygen supply. After 1–3 days of earthing, most of the 59 patients in his study revealed improvement of the following symptoms: fever, dyspnea, cough, weakness, headache, chest pain, loss of senses of taste and smell, anorexia, and body pain.

Health on the 10th floor

Dr Gaétan Chevalier has discussed evidence that living in high-rise buildings can have adverse health effects [61].

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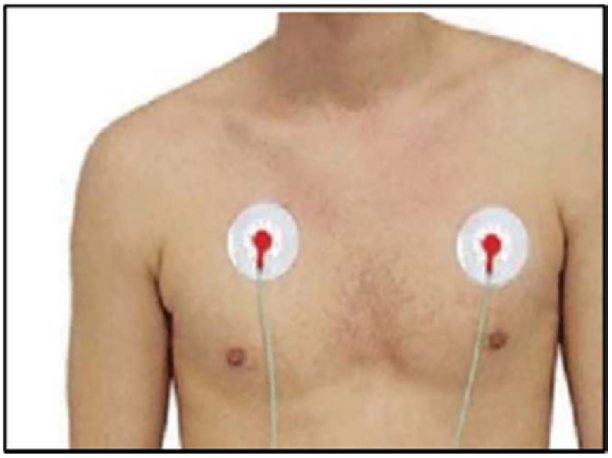

Fig. 7 Fast relief from severe respiratory distress from Covid-19 by placing grounding patches over each lung. Wires plug into ground port of the electrical system.

Specifically, in 2009, Wolinsky and colleagues, using data from a large, nationally representative sample of older people (>70 years) on Medicare, showed that significant stroke risks are associated with living in multi-story residential dwellings versus single-story residential homes [62]. They also reported that in 2005 about 150,000 Americans died from their strokes, placing stroke as the third leading cause of death in the U.S.

To understand how this information may relate to Earthing, refer to Fig. 8 [63]. Note that a person who stands on the surface of the earth while wearing insulated shoes will have an electrical gradient in their body with the top of their head some 200 V positive with respect to the ground. This does not happen if one is grounded. The electrical gradient on the ungrounded person increases as they move to higher floors of a building. Some advice for people living at higher floors in multi-story building is to test the electrical field on their bodies to determine how much they are being stressed by the ambient electrical fields. Dr. Chevalier has written a brief summary of the method for making such measurements [64].

Low on energy?

Finally, extensive unsolicited feedback from Earthing enthusiasts has indicated that many feel more energetic after Earthing. An example from England: "I was feeling really rundown and sluggish, no energy whatsoever. A bit skeptical at first, I got a grounding mat for home and office. Since I started grounding myself, I've felt and slept sooo much better, and seem to have way more energy than before" [65]. This energetic effect should not be surprising, since the primary energy molecule in the body, adenosine triphosphate (ATP) is produced by the electron transport chain in mitochondria. While this has not been studied directly, electron deficiency, caused by infrequent grounding, could result in a deficiency of electrons for the mitochondrial electron transport chain. The grounded or earthed body is expected to have abundant electrons for the mitochondria in every cell in the body.

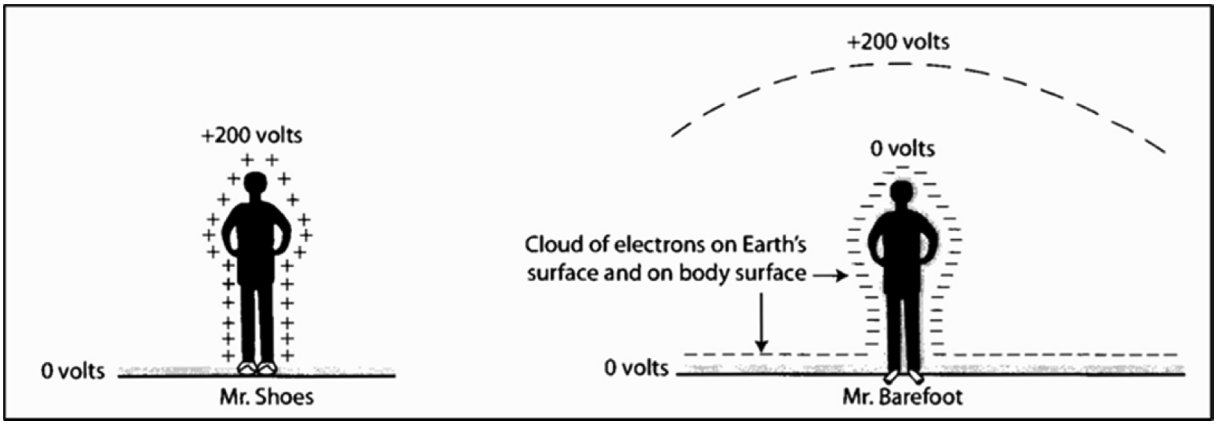

Fig. 8 The surface of the earth has an abundance of electrons that give it a negative electrical charge. Left, if you are standing outside on a clear day, wearing shoes or standing on an insulating surface like a wood or vinyl floor or asphalt, there is an electrical charge of some 200 V between the Earth and the top of your head. Right, if you are standing outside in your bare feet or wearing conductive shoes, your whole body is in electrical contact with the Earth's surface. Your body is a relatively good conductor. Your skin and the Earth's surface make a continuous charged surface with the same electrical potential. Also, notice in the diagram on the right that the charged area is pushed up and away from your head if you are grounded. Any object in direct contact with the earth-a person, a dog, or a tree-creates this shielding effect. The object is essentially residing within the protective "umbrella" of earth's natural electric field. This protective phenomenon also occurs inside your house or office if you are connected to the earth with an earthing device, such as a grounding wrist pad or a foot pad. Reproduced from Ober C, Sinatra ST, Zucker M. Earthing: The Most Important Health Discovery Ever? Laguna Beach, CA: Basic Health Publications; Second Edition, 2014, p. 76 [63].

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Conclusions

The earthing or grounding studies can be summarized with the statement that connecting with the earth is easy and can have many benefits. It is something anyone can try without cost by simply removing their shoes and socks and walking barefoot on the grass or on wet sand at the beach. Moreover, various methods have been developed to bring an earth connection into the home or office. It has been suggested that this is important for those wishing to avoid chronic illness and for those needing to recover from a chronic illness or serious injury of any kind. The research on earthing has revealed a new picture of the nature of inflammation and the reason it can lead to chronic and autoimmune diseases. We can see that the inflammatory barricade, which was recognized in ancient times and is still accepted by Western medical science, as a common response to injury, does not have to form. Prevention of chronic inflammation is accomplished by having the body's tissues saturated with electrons that can prevent "collateral damage" to healthy tissues adjacent to an injury, provided that the person is grounded, and provided the living matrix is functioning properly. Likewise, it is possible that earthing can slow the progression of aging by protecting cells and tissues from oxidative damage caused by reactive oxygen species, ROS, often referred to as free radicals.

Note that the author of this article is not engaged I rendering professional advice or health services. The ideas, procedures, and suggestions in this article are not intended as a substitute for consulting with your physician. All matters regarding your health require medical supervision. The author is not liable or responsible for any problems arising from the information or suggestions in this article.

Declaration of competing interest

The author is a biophysicist/cell biologist. For some 20 years, he has been a paid consultant to EarthFx Incorporated, etc. (There were no grants or other funding sources).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bj.2022.10.004.

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