

The Chairman's Curse: Lethal Sitting

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and 1063

The harm of excess sitting is highlighted in 2 articles published in this issue of *Mayo Clinic Proceedings*. Kulinski et al¹ link low physical fitness with sedentariness even when exercise participation is accounted for, while Shuval et al² go a step further; in their longitudinal analyses, sedentariness is shown to ultimately predict cardiometabolic risk. The data from these 2 reports add to a growing body of scientific evidence that excess sitting is lethal.^{3,4} Excessive sitting has been linked to more than 2 dozen chronic diseases and conditions including cardiovascular disease, diabetes mellitus, obesity, hypertension, hyperlipidemia, back pain, ankle swelling, and deep vein thrombosis.⁵ Of concern, going to the gymnasium after work does not offset the harm of sitting, and excess sitting harms lean and obese people alike.³ Studies, thousands of them, drill down to the same point: sitting is lethal.

Some Americans sit for 13 h/d. How can something that we do so much be so dangerous—it seems implausible? But there are other life functions that have proven harmful. For example, take eating: We eat several times every day but do not need convincing as to how harmful eating has become. Eating, like sitting, is life-threatening when done in excess. Environmental design can affect every breath one takes: Consider the plight of an asthmatic on a high smog day in Los Angeles. Even breathing can be dangerous in an injurious environment.

How did global chair seduction come into being without us noticing? The earliest humans, *Homo*, left the forests of Africa on foot. The fossilized Dmanisi skulls found in the republic of Georgia⁶ showed that early *Homo* walked upright. Over 2 million years, progressive human upgrades evolved and these involved increasing the complexity of their brains, walking more progressively erect, and being active for most of the day.⁷ The earliest and most profound inventions—fire, the wheel, bridge building, warfare techniques, fortification, hunting, and agriculture—were all borne from active minds, hands, and bodies.⁸ The Industrial Revolution, 200 years ago, precipitated that greatest shift in human “lifestyle” since our evolution: urbanization. In 1900, less than 10% of the world's

population lived in cities; now more than half of the world's population is city based. The Industrial Revolution seduced people from agricultural communities to sedentary factory-dense cities.⁹ Modernity then stripped people of free thinking to become enslaved by electronic devices.

Once the Industrial Revolution took hold, lethal sitting became inevitable. In the 1800s, factory production lines were invented to diminish the need for a worker to waste time walking.⁹ Soon after that, modern offices were developed with the premise that the fewer minutes workers moved during the workday, the less time was wasted. The 1930s saw the rise of the archenemy—the office chair. Workplace automation and mechanization followed with the introduction of typewriters, Dictaphones, intercoms, and adding machines—all of which diminished movement. By the 1950s, mass-produced and affordable cars came onto the market and people forewent walking to work and drove. Last came desk-based computerization and the conversion of active play to electronic play. It took nature 2 million years to design the walking, dynamic human, and it took those humans 200 years to reverse the art of nature and cram people all day long into chairs. And so, insidiously, the Chairman—the secretive seated overseer—had won.

The physiological impact of converting a traditional ambulatory way of life to a chair-sentenced one is demonstrated by studies in agricultural communities. In Jamaica, for instance, people living in agricultural communities sit *half* as much as weight-matched people living in urban Kingston.¹⁰ Interestingly, urban Kingston dwellers have similar sitting habits as do urban North Americans. Jamaicans living in agriculture communities sit for about 3 hours each day, whereas an average American worker can clock 13 hours of sitting.¹¹ The chair sentence is a mantle of modernity.

One obvious consequence of chair-based living is that sitters expend fewer calories than do movers. Compared with recumbent rest, sitting increases the metabolic rate 5%, whereas walking, even at 1 mph, increases energy expenditure 100%.¹² A work meeting held at a strolling pace expends 150 to 200 kcal more, per

attendee, than does a similar meeting held with the attendees sitting in chairs. Sitting expends almost as few calories as sleeping.

If people who sat more ate less, body weight might remain stable. But people who sit more do not cut their calorie intake appropriately. Over the last 2 centuries, per capita energy intake has *not* decreased.¹³ Modern people burn far fewer calories *and* fail to curb their intake; as a consequence, they eat more calories than they expend. Is it a surprise that *Homo sedentarius* has obesity?

Because modern people are surrounded by chairs—3-legged, 4-legged, wheeled, office chairs, theater chairs, sofas, and car seats—why doesn't everyone have obesity? Lean people must have a secret. To uncover the secret goings-on of the lean, modern office workers donned underwear interlaced with various body posture and movements sensors.¹⁴ The underwear revealed the secret of leanness: People who are lean have high nonexercise activity thermogenesis (NEAT).

NEAT is the energy a person expends in his or her daily life: the calories expended before, during, and after work and while at leisure. Because most people do not indulge in purposeful exercise, NEAT represents the most promising component of human energy expenditure that can be altered. In high-income countries, people sit for most waking hours and have low NEAT. People who are lean have high NEAT, despite the allure of chairdom; they are up and strolling $2\frac{1}{4}$ h/d more than do people with obesity. The lean burn an extra 350 kcal/d of NEAT; it is a powerful engine to stave off obesity.¹⁵

How is NEAT regulated? Why do people with obesity have low NEAT? NEAT and its antithesis, sedentariness, are to a degree biologically controlled. Animal studies demonstrate a complex integrated neural circuitry that drives an animal to increase NEAT or become sedentary. One key neural control center is in the paraventricular nucleus of the hypothalamus. Here, neural mediators such as orexin and neuromedin U activate movement.¹⁶ The potency of these signals is enhanced in animals inbred for leanness. Animals inbred for sedentariness and obesity are less responsive to NEAT signals. In human terms, this implies that some people may be biologically prone to keep moving whereas

others are born to sit. Watch any group of people: some will fidget and appear restless, whereas others sit still.¹⁷ Biology is likely to be important in determining whether a person is a sitter or a mover. However, environmental stimuli are likely to be more important.

Environmental cues are the predominant determinants of sedentariness.¹⁸ The human genome has not substantially changed in 200 years, but over that time the humans' default posture has changed from ambulatory to chair-based. Urban society/environment must be to blame. In the United States, a person's postal code is a key predictor of sedentariness.¹⁹ More specifically, people who live in poverty-dense regions are more likely to be sedentary, and to have diabetes mellitus and obesity, than do people living in wealthier areas. Because poverty is not a personal choice and a person's postal code is not genetically predetermined, societal determinants of sedentariness must override biological forces. For office workers, for instance, modern offices obligate people to sit for most work in front of computers. Also, many major cities, such as Los Angeles, necessitate people to use cars rather than walk. Other societal-environmental predictors of sedentariness include the weather, outdoor safety, domestic violence, and the proximity of homes to parks.¹⁸

If chair-based environments stack the cards against even the best biology, is there any hope? Is *Homo sedentariness* doomed to die from lethal sitting? Outcome-based approaches exist to help people break free of their chairs and get up. The brain responds to move-it stimuli both structurally and biochemically, much like a muscle does. NEAT begets NEAT.

Office, school, home, and even street design can be modified so that NEAT-styled living becomes normative. Offices can incentivize protocols for walking meetings, incentivize leg-based interactions (eg, walk across the office versus e-mail), and install walking tracks or treadmill desks. Active offices not only report improved health but less perceived stress and improved productivity.²⁰ Schools can be designed to promote active learning, and research demonstrates improvement to health, attentiveness, and educational outcomes. Bright, clean, attractive stairwells with visible prompts promote walking up steps better than do poorly lighted, dirty, dank ones.²¹ The potential health

benefits for active cities are great. For San Francisco in 2013, the average person's travel time by foot was 4 min/d. In a leg-based travel-active scenario, average commutes would increase by 18 minutes. The health benefits would be a potential 2404 avoided premature deaths per year. This degree of improved health would rank among the greatest health advances in modern history,²² and health care cost savings in San Francisco would approximate \$34 billion/y. Tested solutions exist to combat sedentariness and thwart the Chairman.

Excessive sitting has insidiously swept through society so that chair addiction has become a hallmark of modernity. The 2 articles in this edition of *the Mayo Clinic Proceedings*, coupled to a wealth of other data, underscore the harmfulness of the chair. Sitting kills more people than smoking because more people sit excessively than smoke, and the health sequelae of sitting are more numerous.³ There are solutions that work to prevent sedentariness, but the challenge of remediation is broad and profound. Will we forsake our legs and let the Chairman win; or will we act? Take a stand and get up!

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