

## Salt and Hypertension: An Evolutionary Perspective

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### Abstract

Despite overwhelming evidence linking increased salt intake to hypertension, the relation is still disputed in some circles. Viewing the introduction of salt to human diet on an evolutionary time scale would help us better understand the role of salt in hypertension. Humans and related species evolved in a salt-free environment over millions of years with intense evolutionary pressure for the selection of salt conserving genes. The recorded history confirms how rare and inaccessible salt has been until recently. Thrusting the species that has exquisitely adapted to very low salt intake into salt surfeit conditions represents evolutionary mismatch with catastrophic health consequences. More than a quarter of human populations suffer from hypertension. World Health Organization (WHO) and many governments have now taken action to reduce dietary intake of salt in an effort to reduce the incidence of hypertension and the associated cardiovascular morbidity and mortality.

**Keywords:** Hypertension; Salt; Cardiovascular morbidity; Selection pressure; Evolutionary mismatch

### Introduction

The World Health Organization 2002 report has ranked hypertension as the number one killer (WHO 2002) and pointed to the evidence that link high salt intake to high blood pressure [1,2]. Noting that salt consumption throughout the world has nearly doubled to up to 18 g/day during the past 25 years along with an alarming increase in hypertension-more than 25% of adults aged  $\geq 25$  have hypertension globally, WHO urged member nations to reduce dietary intake of salt to help decrease the number of deaths from heart disease and stroke (WHO 2007). Yet despite the overwhelming scientific evidence on the role of salt in the genesis of hypertension, some in academic and lay media dispute these recommendations pointing to a few studies that may have been less than conclusive; they claim that the evidence is weak and conflicting, and caution, absurdly, that reducing salt in diet may cause unforeseen harm [3-6]. A broad review of salt on evolutionary and historic time scales shows that high salt in human diet is a very recent and unfortunate phenomenon with devastating health consequences globally.

### Historical Background

The cheap seductive snow-white crystalline salt in saltshakers now ubiquitous in everybody's kitchen is a recent and unfortunate addition to the natural human diet.

Salt, the symbol of the eternal covenant of God with Israel, the salt of the earth in the Sermon on the Mount, salt the white gold, was extremely scarce and difficult to find, extract and purify until two centuries ago. Only after modern geology revealed how abundant it was on earth and when modern technology made it possible to extract and purify large quantities efficiently and cheaply, salt became a hard-to-avoid permanent fixture in the daily life of the common man.

The search for pure salt preoccupied humanity for millennia and influenced history in profound ways. Its preservative property allowed storage of food and had a momentous effect on history allowing humans' transition from a hunter-gatherer to a settled life style, which established salt as an economically commodity. Ancient Chinese texts describe two different methods to extract salt more than 2000 years ago and name 40 different types, and used it in food preservation. The

ancient Egyptians used it in mummification and preservation of food. Salt taxes were an important source of revenue for the ancient Chinese governments [7]. It was used as currency. Roman soldiers were said to receive their monthly pay as salt money, Latin *salarium*. In ancient Libya it was traded for equal weight of gold. Salt was taxed ruthlessly, i.e., the French *gabelle*, which may have incited the French revolution. It led to wars among nations, influenced the establishment of trade routes, such as the ancient Roman *via salaria*, and many cities derived their names from salt, like Salzburg, Hallstatt, Tuzla, etc. Gandhi's 1930 Salt March in defiance of the British Salt Act was the beginning of the end of British rule in India. Thus the recorded human history documents that humans knew and valued even revered salt for nearly 5000 years, because it was needed to preserve food, was extremely scarce, highly coveted, but out of the reach of ordinary people until recently [8,9].

### Evolutionary Perspective

Part of the skepticism on the role of salt in hypertension stems from the sometimes-conflicting results based on either cross-sectional surveys or short-term dietary intervention studies. There is increasing evidence indicating that the effect of salt is complex, mediated by extended and possibly transgenerational exposure, and some effects may be irreversible. It is not surprising therefore those short-term studies may not always yield consistent results. To understand how disruptive the introduction of salt to the modern diet has been we need to take a broader view and examine the role of salt in human health in the evolutionary time scale.

Modern humans and our hominid ancestors evolved over a span of

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two million years in an environment where salt was virtually absent. This is in fact true for most land-based animals stretching to several hundreds of millions of years in evolution. (One can only try to imagine what a challenge it would be for the herbivore *Apatosaurus* (*Brontosaurus*), one of the largest dinosaurs that existed, finding enough salt to consume to the level that modern humans do!) For life forms that have originated in briny waters to free themselves from marine environment and transition to land environment, the development of mechanisms to carry “the sea within us” was necessary [10]. Thus in the environment where humans and our distant ancestors evolved (the environment of adaptedness) there was an intense and unrelenting selection pressure for genes and mechanisms that could preserve the very small quantities of salt ingested in natural diet--barely 0.25 g salt per day. Indeed, all genes identified to date with a link to blood pressure are associated with sodium transport [11]. Without an efficient mechanism to preserve salt its loss in bodily secretions would have fatal consequences as salt is an essential ingredient of our plasma volume. Thanks to a physiology that has evolved over millions of years, all terrestrial animal life forms are exquisitely well adapted to salt scarcity and can survive without regular access to salt supplements; but the reverse is not true. When thrust into salt surfeit conditions, as in the modern diet that contains 10 – 18 g or even more salt per day (50 to 70-fold higher than our natural Paleolithic diet), we pay a price perhaps not in gold but with high blood pressure, kidney failure, strokes and heart disease [12,13].

Worldwide the incidence of hypertension has now reached 25% correlated to the increased salt consumption in the modern diet. There is also evidence linking high salt diet to higher risk of obesity through greater consumption of sugared drinks, stomach cancer, kidney stones, and osteoporosis. This is what evolutionary medicine characterizes as evolutionary mismatch, and hypertension a maladaptation disorder [12,13].

## Anthropologic Evidence

The evidence for the effect of dietary salt on hypertension can be viewed from multiple angles. One example is the aboriginal communities that still exist in the hunter-gatherer life style, like the African Bushmen or the Amazonian Yanomami who have no access to salt in their diet. Their total salt intake is no more than what their natural diet allows, which is only around 0.25 g per day. Hypertension is simply non-existent in such societies [14]. Yet when such communities are urbanized and exposed to the salty modern diet, they do suffer from hypertension and its complications.

## Animal Experiments

The extraordinary experiments conducted in 1995 by Derek Denton in chimpanzees, our closest living evolutionary relatives, showed dramatically that the chimpanzees placed on high-salt diet (12 g per day) developed hypertension, which reversed when they resumed their usual low-salt (0.25 – 0.5 g per day) diet [15]. Among numerous animal experiments particularly worrisome are the studies suggesting that excess salt may have harmful effects on cardiovascular health independent of hypertension. For example, one such study showed that in normotensive Wistar-Kyoto rats high salt intake resulted in deposition of fibrous tissue in the heart and kidneys despite only modest rises in their blood pressure [16].

## Human Studies

In the 1940s when there were no drugs available to treat hypertension, Dr. Walter Kempner treated hundreds of severely hypertensive patients

on a strict low-salt (0.25 g per day) diet based on rice, fruit juices and vitamins (Kempner’s rice diet) for many weeks, some more than a year making this one of the longest salt restriction studies in the medical literature. Meticulous records kept by Dr. Kempner document that the diet markedly improved blood pressure, reversed heart enlargement, improved kidney function and also reversed the retinal blood vessel alterations in these patients [17].

More recent studies although of shorter durations confirmed that low salt diet lowers blood pressure both in individuals with normal blood pressure and in patients with hypertension. Perhaps the best known is the Dietary Approaches to Stop Hypertension (DASH) diet trial. This 12-week controlled trial showed that reducing dietary intake of salt from the “normal” (8 g per day) to intermediate (6g), and low (4 g) lowered blood pressure among both hypertensive and normotensive individuals [18]. Numerous other interventions confirmed that reducing salt intake lowers blood pressure. Consensus has now emerged among most hypertension experts that the beneficial effect of salt reduction starts at daily intake levels of 5 g or less, and the relatively high potassium content of low-salt diets may have additional beneficial effects on blood pressure [19].

## Conclusion

Millions of years of successful existence of our and related species in a salt-free environment should convince the salt skeptics that low-salt diet is natural and safe. The modern man while well adapted to low-salt diet is poorly equipped to cope with the salt surfeit imposed on him in recent times. The evidence is multifaceted and incontrovertible. The unnaturally high salt intake, an artifact of recent times, contributes to hypertension and to the increased cardiovascular morbidity and mortality caused by hypertension. Reducing daily salt intake to approximately 5 g per day helps lower blood pressure and reduces the complications of hypertension, can help cut health care expenditures and save millions of lives worldwide [2,20].

Despite the overwhelming evidence linking excess dietary salt intake some continue to debate the existence of this relation. Fortunately, world governments faced with the economic burden caused by the ravages of hypertension and the associated cardiovascular morbidity have started to take action. A worldwide campaign to reduce dietary salt intake to a modest 5-6 g/day has been undertaken [21]. Finland and England have already reduced the amount of salt being consumed by a combined policy of getting the food industry to decrease the amount of salt added to foods, labeling the sodium content on food products, and increasing public awareness of the harmful effects of salt on health. However, a global approach is required to extend these measures to developing countries where approximately 80% of world’s hypertension-related disease burden exists. Experience has shown that even a modest reduction in salt intake can result in major improvements in public health and lead to cost reduction in healthcare expenditures. A worldwide coalition, World Action on Salt and Health (WASH) has now been launched encouraging other countries and healthcare professionals interested in hypertension, kidney and heart diseases to join in this effort [21].

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