DRINKING WATER BEFORE THIRST STIMULATION COULD DECREASE DAILY SALT INTAKE

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Background: The current recommendations to reduce salt intake from 9–12 g/d to 5–6 g/day will have a major effect on blood pressure and cardiovascular disease but are not ideal. A minimal increase in the plasma osmolality of 1–2% induces thirst, hypovolemia, hypotension, and angiotensin II are the most known of thirst stimuli. Certain stimuli for thirst and salt appetite are common; hence, following thirst stimulation, salt appetite is increased. The objective of this study is to determine the effect of water deprivation in *Ramadan* (Islamic month of fasting) on daily salt intake in fasting people and comparison with *Shaa'ban* (the month before *Ramadan*) as control. **Method:** Thirty male fasting students were selected for the experiment and their 24-hrs urinary sodium excretion was measured during one day of *Shaa'ban* and one day of *Ramadan*. An increase and decrease more than 15% in 24-hours urine sodium was considered as remarkable changes. **Results:** Five specimens were eradicated from the study owing to recommendation regarding 24-hrs creatinine excretion criteria. Changes in 24-hrs urine sodium during *Ramadan* in comparison with *Shaa'ban* were unremarkable in 7 specimens. Remarkable decrease and increase (fluctuation over 15%) were observed in 10 and 8 specimens respectively. **Conclusion:** Similar to the effect of fasting on weight, blood pressure, and appetite, fasting has a double effect on salt consumption. As during fasting, other parameters in addition to thirst affected salt appetite, hence the sole effect of thirst on salt appetite was covered by other parameters. Nevertheless, drinking water before thirst stimulation could decrease daily salt intake

Keywords: Fasting, *Ramadan*, Salt appetite, Salt intake, *Shaa'ban*, Water deprivation

INTRODUCTION

Blood pressure (BP) is the major risk factor for cardiovascular disease such as stroke, myocardial infarction and cardiac failure in the general population.[1] Hypertension is a complex disease caused by genetic and environmental factors. Among the dietary factors salt intake is one of the most important.[2] The 'INTERSALT' population study is a collaborative study of the relationship between blood pressure (BP), sodium and potassium intake in more than 50 population samples in 32 countries.[3] The modern literature concerning the relationship between salt and BP in humans really begins in the 1960s with the work of Lewis Dahl. He correlated the prevalence of hypertension in five geographically distinct populations with their average daily salt intakes and proposed that BP rises linearly with salt consumption.[4] Observational data indicate a strong positive association between sodium intake and blood pressure within and between populations.[5] Chronic high salt intake increases cardiovascular morbidity and mortality both by its influences on blood pressure and by pressure-independent effects on the blood vessels and heart.[6] Extensive epidemiological literature has already documented the correlation between salt intake and blood pressure (BP) or the prevalence of hypertension.[7]

Salt restriction is now also widely promoted as an effective non-pharmacological approach to managing mild hypertension, as well as an important adjunct to pharmacological treatment in moderate and severe hypertension.[8] Actual minimum requirements for sodium are not known but have been estimated to be as low as 200 mg/day. The mean daily salt intake in Western societies is about 10 to 12 g (4 to 5 g of sodium) per capita, far in excess of the estimated minimum requirements. Approximately 3 g of the daily salt exist naturally in foods, 3 g is added during processing, and 4 is added by individual.[9]The current recommendations to reduce salt intake from 9 to 12 g/d to 5 to 6 g/d will have a major effect on blood pressure and cardiovascular disease but are not ideal. A further reduction to 3 g/d will have a much greater effect and should now become the long-term target for population salt intake worldwide.[10] The minimum daily intake required for physiological stability in salt and water balance can be assumed to be between 1 and 10 mmol Na/d, based on data on salt and blood pressure in remote populations, and there is a continuous positive correlation relationship between salt intake and blood pressure across the range of dietary intake, from <1 mmol Na/d in Yanomami populations to >250 mmol Na/d in some industrialized populations.[11] A decrease in Na^+ intake will lower blood pressure (BP) in hypertensives, reduce the need for pharmacological therapy and prevent the development of hypertension. Consequently, without exception, all major guidelines express the opinion that part of life-style management should include a reduction in Na^+ intake. The most recent consensus indicates that this should be far less than 65 mmol/day (1.5 g of Na^+/day).[12] A reduction in salt intake necessitates changes in food patterns: the sodium content of foods and the consumption of foods that contain large amounts of salt should be reduced. Engstrom and Tobelmann showed that a reduction in the intake of high-sodium foods could lead to reduced intakes of calcium, iron, magnesium, and vitamin B_6 from the diet.[13]

Therefore, the target of 5 to 6 g/d should be seen as an interim target, and the long-term target for population salt intake worldwide should now be 3 g/d. This will be difficult, particularly because in most developed countries, 75% to 80% of salt intake now comes from salt added to processed foods. The strategy should be that the food industry should gradually reduce the salt concentration of all processed foods, starting with a 10% to 25% reduction, which is not detectable by consumers, and continuing a sustained reduction over the course of the next decade.[10] Any strategy for salt intake reduction should be focused on balancing these three above mentioned objects. Four gram of daily salt intake is added by individual, eradication of this part of salt intake depend on finding a reasonable way for salt appetite reduction. Certain stimuli for thirst and salt appetite are common; hence, following stimulation of thirst, an increase in salt appetite occurred. The average sodium intake for individuals in industrialized cultures eating processed foods usually ranges between 100 and 200 mEq/day, even though humans can survive and function normally on 10 to 20 mEq/day. Thus, most people eat far more sodium than is necessary for homeostasis. The kidneys have an amazing capability to match their excretion of salt and water to intakes that can range from as low as one tenth of normal to as high as 10 times normal.[14] The kidneys are the major route for excretion of NaCl from the body.[15]

In lunar year, Shaban is the previous month of Ramadan, Moslems are not bound for fasting during Shaban. Ramadan is one of the important months for Moslems, during this month, in addition to usual religious customs, Moslems should be fasting the whole day. Sustained fasting over a period is a feature of several of the world's great religions. One of the five fundamental rituals of Islam is fasting during the month of Ramadan. Muslims neither eat nor drink anything from dawn until sunset. Fasting begins before sunrise and ends after sunset, depending on geographical area and season, fasting period varies from 11–16 hours in a day. In this period, the individuals should abstain from drinking and eating. The objective of this study is to determine the effect of water deprivation on the rate of salt intake in fasting people in Ramadan (The month of fasting in Islam) in comparision to *Shaa'ban*.

MATERIAL AND METHODS

This study was performed at the Department of Physiology, Faculty of Medicine, Zanjan University of Medical Science, Iran during *Shaa'ban* and *Ramadan* 2005 (Islamic year 1427). Prior to the initiation of experimentation, study protocols were reviewed and approved by the ethical committee from the research office of Zanjan University of Medical Science. All work conducted in accordance with the Declaration of Helsinki. The *Shaa'ban* in lunar year of 1427 coincide with 15 August to 12 September 2005 and *Ramadan* with 13 September to 12 October 2005. The duration of fasting in Zanjan city during Ramadan 2005 take 14.5 hours. All of the subjects for this study were selected among healthy students of ZUMS and who indicated that they were going to fast during Ramadan, and aged 20–35 years. Volunteers gave informed consent for participation in the study, questionnaire forms were filled by students and finally 30 male students were selected among healthy and fasting students. Sampling was done by non-probability sampling, the general conditions of students who were selected as our samples include: No records of consuming cigarette and tobacco product, no records of suffering from renal diseases, no records of special diseases. We excluded students with any acute or chronic disease or medication during the study and any addiction.

All subjects followed the same dietary regimen before and during Ramadan and were encouraged to continue their usual lifestyle and activities. In order to avoid of any bias during this study, the individuals were not informed about the consistency of the project. The students trained for correct way of 24-hrs urine volume collection and were carried out under free-living condition and the students were informed avoidance from exercise in these days. The exact weight of each volunteer was measured and recorded before each sampling. The completeness of the collection was ascertained from the subjects and was confirmed on the basis of 24-hrs creatinine excretion. In whom their creatinine excretion rates in 24-hrs urine was less than 70% of minimum expected creatinine excretion (10 mg/kg/day) in 24-hrs urine volume were eradicated from the study. If the 24-hrs creatinine excretion was within 30% of the estimated values, the urine collection was considered successful.[16] Sodium concentrations in urine were determined by using ion-selective electrodes (Kone Microlyte Ion Selective Analyzer; Kone Corporation, Espoo, Finland). Creatinine concentrations in urine were analyzed by using the Jaffé method (Boehringer Mannheim GmbH, Mannheim, Germany). Depending on habitual diet, the rate of daily salt intake is approximately constant in most people, on the other hand, the rate of daily salt intake in different days could be variable. A fluctuation more than 15% in 24-hrs urine sodium excretion was considered as remarkable changes. With attention to this fact that obese individual consume more salt than ordinary people, their sodium excretion in 24-hrs urine is comparatively higher. Hence, neperien logarithm of excreted salt and creatinine proportion in 24-hrs was employed to demolish any physical status interference in obtained results. The data was presented as Mean±SD. Statistical analysis of data (Serum sodium level and Plasma osmolarity) was performed using analysis of variance test with the help of SPSS Software, version of 11.5 and 'paired-test'. A minimum significance level of $p<0.05$ was used for all comparisons and $p<0.05$ was considered as significant changes.

RESULTS

Out of 30 specimens, 5 of them were omitted from the study owing to recommendation regarding 24-hrs creatinine excretion criteria and the rest of 25 volunteers were included in the study. The mean age of volunteers was 26.4±1.3 years with minimum of 24 and maximum of 29 years. The mean weight of volunteers was 75.2±11.3 Kg with minimum of 59 and maximum of 102 Kg. The minimum and maximum of 24-hrs urine volumes in *Shaa'ban* was 560 and 2850 ml respectively and the mean 24-hrs urine volume was 1260.8±581.93 ml. The minimum and maximum of 24-hrs urine volumes in *Ramadan* was 510 and 2110 ml respectively and the mean 24-hrs urine volume was 1075.6±391.50 ml. Table-1 compared 24-hrs urine volume between *Shaa'ban* & *Ramadan*, *p*-value=0.475, the difference between mean urine volumes in *Shaa'ban* and *Ramadan* was not significant. The minimum and maximum amount of 24-hrs urine sodium excretion was 80 mEq (4.5 g salt) and 300 mEq (17.5 g salt) in *Shaa'ban* respectively, the mean 24-hrs urine sodium excretion was 171.6±50.5 mEq (10 g salt). The minimum and maximum amount of 24-hrs urine sodium excretion was 95 mEq (5.5 g salt) and 220 mEq (12.9 g salt) in *Ramadan* respectively, the mean 24-hrs urine sodium excretion was 158.4±33.8 mEq (9.2 g salt). Table-2 compared 24-hrs urine sodium excretion between *Shaa'ban* & *Ramadan*, *p*-value=0.149, the difference between Mean urine sodium excretion in *Shaa'ban* and *Ramadan* was not significant changes in 24-hrs urine sodium excretion in *Ramadan* with *Shaa'ban* is as follow: In 40% of cases (10 individual), the amount of 24-hrs sodium excretion during Ramadan in comparison to *Shaa'ban* reduced more than 15%, in 32% of cases (8 individual) the amount of 24-hrs sodium excretion during Ramadan in comparison to *Shaa'ban* increased more than 15%, and the fluctuation lower than 15% was observed in 28% of cases (7 individual).

The minimum and maximum amount of 24-hrs urine creatinine excretion rate was 630 and 1448 mg in *Shaa'ban* respectively, the mean 24-hrs urine sodium excretion was 924.5±249.2 mg. The minimum and maximum amount of 24-hrs urine creatinine excretion rate was 612 and 1613 mg in *Ramadan* respectively, the mean 24-hrs urine sodium excretion was 968.2±245.2 mg. The mean difference of 24-hrs urine creatinine excretion rate in *Ramadan* with *Shaa'ban* was 43.6 mg. (p=0.165), the difference between Mean 24-hrs urine creatinine excretion rate in *Shaa'ban* and *Ramadan* was not significant. Table-3 compared 24-hrs creatinine excretion rate between *Shaa'ban* & *Ramadan*. Analysis of the results shows that mean value of Ln (salt 24-hrs/Cr 24-hrs) during *Ramadan* (2.26) was lower than *Shaa'ban* (2.37) which the rate of difference was 0.11±0.38. In spite of the eradication of physical factor, the difference was non-significant statistically (p=0.173). Table-4 compared the Logarithm neperien (Ln) (salt 24-hrs/Cr 24-hrs) during *Ramadan* with *Shaa'ban*.

Table-1: Comparison of 24-hrs urine volume between *Shaa'ban* & *Ramadan*

24-hrs urine volumes	Number of specimens	Minimum	Maximum	Mean±SD
24-hrs urine volume in Shaban	25	510	2850	1260.8±581.93 mL
24-hrs urine volume in Ramadan	25	510	2110	1075.6±391.50 mL*

**p*-value 0.475 or >0.05 when Mean urine volumes in *Shaa'ban* and *Ramadan* was compared.

Table-2: Comparison of 24-hrs urine sodium excretion between *Shaa'ban* & *Ramadan*

24-hrs urine Sodium	Number of specimens	Minimum	Maximum	Mean±SD
24-hrs urine sodium excretion in *Shaa'ban*	25	80	300	171.64±50.54 mEq
24-hrs urine sodium excretion in *Ramadan*	25	95	220	158.44±33.87mEq*

**p*-value 0.149 or >0.05 when Mean urine sodium excretion in *Shaa'ban* and *Ramadan* was compared.

Table-3: Comparison of 24-hrs creatinine excretion rate between *Shaa'ban* & *Ramadan*

24-hrs creatinine excretion	Number of specimens	Minimum	Maximum	Mean±SD
24-hrs creatinine excretion in *Shaa'ban*	25	630	1448	924.56±249.26 mg
24-hrs Creatinine excretion in *Ramadan*	25	612	1613	968.2±245.20 mg *

**p*-value 0.165 or > 0.05 when Mean creatinine excretion rate in *Shaa'ban* and *Ramadan* was compared.

Table-4: Comparison of Ln (salt 24-hrs/ Cr 24-hrs) between *Ramadan* & *Shaa'ban*.

Ln (salt 24-hrs/Cr 24-hrs)	Number of specimens	Mean±SD
Ln (salt 24-hrs/Cr 24-hrs) In *Shaa'ban*	**25**	**2.37±0.36**
Ln (salt 24-hrs/Cr 24-hrs) In *Ramadan*	**25**	**2.26±0.37***

*p-value 0.173 or >0.05 when Ln (salt 24 hours/Cr 24 hours) between *Shaa'ban* and *Ramadan* was compared.

DISCUSSION

The present study produced several key results in relation to the effect of water deprivation in Ramadan on the rate of salt consumption in fasting people and comparison with *Shaa'ban*. First, the mean 24-hrs urine volume in *Ramadan* (The month of fasting in Islam) was 175 ml, about 15% Reduction, lower than *Shaa'ban* (8th month of Islamic calendar or the month before *Ramadan*, which means people consume more fluid in *Shaa'ban* in comparison to *Ramadan*. Living things usually consume two fold fluid more than food, a reduction in water intake indicated that the amount of food consumption decreased too. Reduction in food consumption decreased salt load in fasting people. Second, the mean 24-hrs urine sodium excretion in *Ramadan* (The month of fasting in Islam) was 13.2 mEq, about 8% Reduction, lower than *Shaa'ban*, (8th month of Islamic calendar or the month before *Ramadan*) which means people consume more sodium in *Shaa'ban* in comparison to *Ramadan*. The mean 24-hrs urine sodium excretion in Ramadan was lower than *Shaa'ban*, but this difference was not significant. Third, during *Ramadan* the amount of 24-hrs sodium excretion showed reduction in more than 15% in 40% of cases (10 individual), increase in more than 15% in 32% of cases (8 individual) and in 28% of cases (7 individual) moderate fluctuation less than 15% were observed. Forth, the mean 24-hrs urine creatinine excretion rate in *Ramadan* was 43.6 mg, about 15% Increase, higher than *Shaa'ban*. Fifth, the mean value of Ln (salt 24-hrs/Cr 24-hrs) during *Ramadan* (2.26) was lower than *Shaa'ban* (2.37). Even though, this parameter in *Ramadan* was lower than *Shaa'ban*, but this difference was not significant. Fasting for about 12–16 hours during Ramadan could affect most body system deeply, the effect of fasting on Blood pressure, weight and appetite in all of the people is not similar, and these effects are binary. For example, the effect of fasting on appetite is binary, In some people, fasting stimulates appetite and in the evening individual could consume food more than usual, but in some other people fasting suppress appetite and individual consume less than usual. The rate of food consuming could affect the rate of salt consumption and sodium load. Similar to the effect of fasting on appetite, the effect of fasting on salt appetite is binary, as this matter previously discussed. Blood volume decrease, Blood pressure decrease and thirst should be considered as the main stimuli for salt appetite, that is why after each stimulation of thirst sensation and subsequent quenching the individual shows great interest for consuming salty food. However, the net effect of thirst on salt appetite in this study was not obvious, but we emphasized that an increase in water consumption decreases salt appetite, because the thirst stimulation and salt appetite are common.

We cannot survive without sufficient intake of water and electrolytes to replace the obligatory losses that occur through the skin and lung and in the urine and feces.[17] Daily loss of body water through insensible and sensible water loss is about 2300 ml, the total water intake is about 2,300 ml/day. Intake of water, however, is highly variable among different people and even within the same person on different days, depending on climate, habits, and level of physical activity.[14] In mammals, a minimal increase in the plasma osmolality of 1–2% induces thirst. A decrease in the extracellular fluid volume, although less effective, is also capable of generating thirst. A 10% reduction in blood volume or in arterial pressure both will induce an animal to drink water. Sodium intake occurs later, but initially the animal looks for water.[18] The correction of extracellular hypovolemia requires the ingestion of not only water but also of solute, such as ionic sodium, which does not readily cross the cell plasma membrane and remains in the extracellular space. Both thirst and salt appetite-related behaviours promote the expansion of extracellular fluid volume.[19] Sodium appetite and thirst are recognized complementary motivational states that drive a dehydrated animal to refill its major fluid compartments.[20] The precise regulation of the volume and osmolality of body fluids is fundamental to survival. All vertebrates maintain plasma osmolality and extracellular volume primarily by regulating the ingestion and urinary excretion of water and electrolytes.[21]

The obtained results in this study coincide with similar findings released by other researchers. Water homeostasis has had a major survival role in the terrestrial environment. The same is true for sodium homeostasis. Water deprivation challenges both and thereby elicits appropriate mechanisms that assure the replacement of water and sodium. Therefore, water deprivation relates not only to thirst, but also to sodium appetite, thus leading to a new equation where water deprivation= thirst±sodium appetite. Thirst and sodium appetite: two sides of the same coin? One guess is that water deprivation may contribute to the human craving for salt. Salt preference increases in humans subjected acutely to a protocol similar to the WD-PR. Repeated episodes of sodium depletion in rats lead to an enhanced sodium consumption that may share neural mechanisms with addiction and recently we have shown that rats with a history of repeated episodes of water deprivation have increased daily sodium consumption.[20] An increase in daily water intake had different useful effects on body systems and these effects revealed in previous studies. With attention to this fact and limited numbers of studies performed on this field, future comprehensive and applied studies are strongly recommended in this field.

CONCLUSION

Similar to the effect of fasting on weight, blood pressure, and appetite, fasting has a double effect on salt consumption. As during fasting, other parameters in addition to thirst affected salt appetite, hence the sole effect of thirst on salt appetite was covered by other parameters. Nevertheless, drinking water before thirst stimulation could decrease daily salt intake

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