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Sodium and Potassium Nutritional Status Provides a New View on the Essential Hypertension

Berislav Momčilović

Abstract

Short-term biological indicator of urinary Na and K excretion is generally used to assess Na and K dietary exposure. In this study, we used the long-term biological indicator of hair to assess Na and K nutritional status. Hair Na and K were analyzed in 1073 healthy adult white Caucasians [734 women (♀) and 339 men (♂)] with the ICP MS. The log-transformed data were analyzed with median derivatives bioassay. The median values (μg·g⁻¹) were ♀Na 254 and ♂Na 371, and ♀K 74.3 and ♂K 143, respectively. The linear (adequate) ranges of the sigmoid saturation curve ranges for sodium were ♀Na 55.6–1307 and ♂Na 84.0–1450, whereas these ranges for potassium were ♀K 18.9–467 and ♂K 25.8–1079. The strict homeostatic control of whole blood K and Na renders them unsuitable for assessing the nutritional status. The potassium to sodium ratio (K/Na) in women appears stable across the sigmoid linear segment range, contrary to the constantly increasing K/Na ratio in Men. The results suggest that hair Na concentration should not be below 55.6 and 84.0 or above 1307 and 1450 μg·g⁻¹ in women and men, respectively. Similarly, K hair concentrations should not be below 18.0 and 25.8 and higher than 46.7 and 107.9 in women and men, respectively. Hair K/Na ratio should stay about 0.600 in M and 0.400 in W. Current dietary salt exposure of the general US population does not require preventive across the board salt restriction.

Keywords: potassium, sodium, hair, whole blood, nutritional status, essential hypertension

1. Introduction

Sodium and potassium are the principal extracellular and intracellular cationic elements of the human body, respectively [1]. However, the link between habitual salt dietary intake and general public health is still controversial [2]. Over the last decades, a plethora of studies informed us how excess dietary salt is associated with hypertension and cerebral stroke [3–5]. That leads to the recent draconian recommendations for the general population for the dietary salt restriction [6]. However, the deeply echeled crusade against what is now the habitual dietary salt intake is strongly criticized because of the flaws of many studies statistical design and “cherry picking”
of the data [7], that the basic tenants of the human physiology were either ignored or misinterpreted [8] and that there were too much bureaucratic political meddling in the salt restriction issues [9].

The simple idea on how the reduction of sodium dietary intake may be a health protection measure for the general population to prevent the development of hypertension and cerebral stroke is certainly a very appealing one. That idea has been tested by a waste number of authors who studied the relationship between blood pressure and dietary sodium and potassium intake and their urinary excretion (separately or in combination), and what comprehensive review is beyond the aim of this article. Indeed, there are difficulties associated with the timing and assessing of the correct blood pressure readings [10], the problem with the control of the complex variability of the tested dietary composition [11, 12], and the problems on how to adequately assess the dietary intake of either sodium and potassium [13, 14].

The aim of this research is to assess sodium and potassium nutritional status by analyzing their frequency distribution in the hair and whole blood of adult men and women with a median derivatives bioassay [15]. Today, a century-old dictum “We are what we eat” may be modified to run “Hair knows what we eat” [16]. Indeed, hair is the long-term biological indicator of the bioelement nutritional status, whereas the current “golden standard” of the urine is a short-term biological indicator [17]. It should be noted that we used the term “bioelement” as a common denominator for the major elements (electrolytes) like Na and K, trace elements like I and Se, and ultra-trace elements like Cr and Ni [15].

2. Subjects and methods

This prospective, observational, cross-sectional, and the exploratory epidemiological study was approved by the Ethical Committee of the Institute for Research and Development of the Sustainable Eco Systems (IRES), Zagreb, Croatia. The study was conducted in adherence to the Declaration of Helsinki on Human Subject Research [18]. Every subject gave his/her written consent to participate in the study and filled out a short questionnaire on his/her health status and medical history (data not shown) [19]. Data on hair shampooing were also recorded and none of them declared the presence of elements under the observation.

Hair potassium and sodium were analyzed in a random sample of 1073 apparently healthy white Caucasian adults (339 men, 734 women). Whole blood K and Na were analyzed in a subset of 212 subjects (143 women and 91 men); the median age of women and men was 47 and 50 years, respectively. Our population consisted of subjects from the general Croatian population who were interested to learn more about their health status; the majority of them were living in the capital city region of Zagreb, Croatia. All the subjects consumed their usual home-prepared mixed mid-European diet, and none of them have reported an adverse medical health condition.

Hair K and Na and whole blood K and Na were analyzed with the inductively coupled plasma mass spectrometry (ICP-MS, Elan 9000, Perkin Elmer, Canada) at the Center for Biotic Medicine (CBM), Moscow, Russia. The CBM is an ISO Europe certified commercial laboratory for analyzing bioelements (electrolytes, trace elements, and ultra-trace elements) in different biological matrices in health and disease. CBM is also a member of the exclusive External Quality Assessment of the UK Surrey scientific group for the quality control of trace element analysis. Hair K and Na
analyses were performed following the International Atomic Energy Agency recommendations [20] and other validated analytical methods and procedures [21].

Preparation of hair and whole blood for the ICP-MS analysis is described in Appendix A, Part A for the hair and Part B for the whole blood. The detection limits for K and Na in the hair were 4.3 ppm for Na and 0.3 ppm for K, and in the whole blood, they were 0.6 ppm for Na and 0.04 for K. All chemicals were of pro analysis grade (Khimmed Sintez, Moscow, Russia).

To scrutinize the respective hair and whole blood potassium and sodium concentration frequency distribution, we used the median derivative bioassay of the log-transformed data, to fit the sigmoid logistic regression function (power function) [22] for men and women separately (Appendices B and C)

\[
A_2 + \frac{(A_1-A_2)}{[1 + (x/x_0)^p]}
\]

(1)

Where A1 is the initial value (lower horizontal asymptote), A2 is the final value (upper horizontal asymptote), x0 is the center (point of inflection) is the median (M0 detected), p is power (the parameter that affects the slope of the area about the inflection point). The OriginPro 8.0 data analysis and graphing software was used for this analysis (OriginLab Corp., OriginPro Version 8.0., Northampton, MA).

The hair deposition of a K and Na below the linear segment range of the sigmoid saturation curve denotes a deficient hair uptake of K and Na; when their concentration is within the linear range segment that indicates a safe and adequate hair K and Na uptake, and when K and Na concentrations are above the linear range segment of the sigmoid power curve, that denotes the excessive level of their hair uptake [23].

The central adequate linear segment of the sigmoid power curve may be further subdivided into low adequate, safe, and supra-adequate segments with a 60:30:10 ratio [17], but some other ratios, like 30:60:10 ratio, may be also considered. It is well known that our body may adapt to a given nutrient intake so that balanced nutrition can occur at various dietary levels of the nutrients. Thus, sparse diets are not necessarily deficient ones, although they often are [23].

3. Results

To correct for the exponential pattern of the data distribution, we log-transformed the potassium and sodium hair and whole body concentration data for men and women separately. Such a data transformation generated a classical Gaussian bell-shaped frequency distribution. Hair potassium data frequency distribution for both men and women is shown in the upper left part of Figure 1, whereas the data for sodium frequency distribution is shown in the lower left part of the same figure. The hair of both men and women has higher concentrations of sodium than potassium. Indeed, hair sodium median concentrations were (μg g⁻¹) 371.5 for men (M, ♂) and 254 for women (W, ♀), whereas the comparative hair potassium concentrations were lower for both M•K 142.5 and W•K 73.7 (Figure 2A). The median potassium to sodium ratio (K/Na R) was 0.385 for M and 0.298 for W, respectively (Table 1).

Similarly, whole blood (WB) concentrations were also higher for sodium than potassium (Figure 3A). WB medians for sodium were M•Na 178 and W•Na 181 μg g⁻¹, whereas WB potassium medians were M•K 1369 and W•K 1324, respectively. The K/Na median ratios were M•K/Na 0.769 and W•K/Na 0.731 and they were almost identical with the overlapping CV intervals. It should be noted that WB potassium...
Gaussian distribution showed a tendency of slightly leaning to the right, whereas, contrary to that, sodium showed a tendency to lean to the left, which indicates subtle sex potassium and sodium metabolic differences.

Our median derivatives bioassay allowed for the transformation of the Gaussian bell-shaped frequency distribution curves for hair potassium and sodium into their sigmoid saturation curves (Figure 2A for K and Figure 2B for Na). The numerical data for the shown median derivatives points are presented within Appendix C.1 for potassium and Appendix C.2 for Sodium. The sigmoid saturation curves started being linear at the median derivative points $W \cdot d_3$ and $M \cdot D_3$ but the linear upward trend started earlier in women than in men. However, the linear segments for both men and women sigmoid saturation curves for hair potassium would fuse together again at the median derivatives upward point of $W \cdot u_3$ and $M \cdot U_3$. However, the linear medium derivatives range segments for hair sodium get merged much earlier for W at $u_1$ and for M at $U_1$, respectively. We assume that the observed suggests a tighter metabolic control of sodium than potassium in both men and women.

The median derivatives bioassay data for whole blood (WB) generated almost vertical steep and narrow linear ranges for both men (Figure 3A) and women (Figure 3B). Indeed, the linear segments of the median derivatives between men and women for the same bioelement were almost identical. However, potassium and sodium WB concentrations were both higher in men than women. The data demonstrated impressively tight homeostatic control of WB sodium and potassium for both
sexes. Such a tight control implies poor WB adequacy in assessing both Na and K dietary intake impact.

We also directly cross-compared the relationship of hair Na and K concentrations over their median derivatives linear range (Figure 4). Apparently, there is a difference in K and Na quantitative saturation along with the hair fiber. Since even the sparse diets may be nutritionally adequate, it is reasonable to assume that the initial linear part of the sigmoid saturation curve presents the subclinical or low adequate range.

Table 1.

Potassium/Sodium ratio of the linear part of the sigmoid saturation curve (μg g⁻¹).

<table>
<thead>
<tr>
<th></th>
<th>Minimum (D2)</th>
<th>Median (U2)</th>
<th>Maximum (U2)</th>
<th>Minimum (D2)</th>
<th>Median (u2)</th>
<th>Maximum (u2)</th>
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<td>Potassium</td>
<td>10.3</td>
<td>355.9</td>
<td>1100.5</td>
<td>20.6</td>
<td>81.6</td>
<td>483.9</td>
</tr>
<tr>
<td>Sodium</td>
<td>91.2</td>
<td>364.3</td>
<td>1577.3</td>
<td>60.9</td>
<td>279.9</td>
<td>1377.2</td>
</tr>
<tr>
<td>K/Na</td>
<td>0.113</td>
<td>0.420</td>
<td>0.698</td>
<td>0.337</td>
<td>0.296</td>
<td>0.337</td>
</tr>
</tbody>
</table>
nutritional response range. Alternatively, the 30–90% segment of the sigmoid curve linear range represents a truly adequate K and Na dietary intake range. Interestingly enough, the correlation coefficient $r^2$ was impressively high for individual potassium and sodium slopes, i.e., $r^2$ for $M\cdot Na$ was 0.948 and that for $W\cdot Na$ was 0.929 whereas $r^2$ for $M\cdot K$ it was 0.865 and $W\cdot K$ was 0.857. However, when comparative data for hair sodium were plotted on the X-axis, and potassium data on Y-axis, the combined $r^2$ correlation coefficient dropped to 0.487. These data indicate that there is a considerable capacity for homeostatic adaptation within the hair follicle to the changes in the available circulating amounts of dietary Na and K. Apparently, the constant and efficient homeostatic control of Na and K in the whole blood is accompanied by their highly variable concentrations in the hair which acts as a river lavvy for water excess.

Collected data showed a tempting impression of how hair Na tends to increase with aging whereas hair K tends to decrease over the same time period (Figure 4). Indeed, there was a significant age-dependent increase of sodium in the hair of women ($p < 0.05$, Pearson’s coefficient), but not in men. Presumably, the number of our men was too small to conclusively show the presumed age-dependent increase of hair Na in men. Or we may be dealing with a problem of the statistical inequality in the mathematical statistics. All in all, the data showed some reflex on sarcopenia, i.e., age-dependent muscle loss in old age, and failure in the control of sodium in old age.
4. Discussion

Human hair makes a valuable long-term biological indicator tissue for the assessment of the nutritional status of the essential bioelements [17, 24, 25]. Hair growth is a unidirectional process that, in contrast to urine, precludes sodium and potassium post absorption metabolic equilibration with the surrounding organs and tissues of the human body [15]. Indeed, the results of our study demonstrated that the human nutritional status of potassium and sodium may be adequately assessed with the hair median derivatives bioassay. This median derivatives bioassay relies on the central part of the Gaussian statistical data distribution curve, i.e., on its linear segment when the data were log-transformed. This is a substantial difference in comparison to the standard statistical approach where we are focused on the data distribution tails. Indeed, the linear segment of the sigmoid curve covers for an entire one standard deviation of the entire population data set. Moreover, the median derivatives bioassay model avoids the problem of J-shaped

Figure 4. Hair potassium/sodium (K/Na) ratio. The squared region over the regression line covers a 30–90% of the adequate nutritional status. Internal red square: women, internal blue square: men.
curves transformation [26] and other problems associated with the no threshold assumption linear regression model [27].

This study revealed subtle gender-dependent metabolic differences in the homeostatic control of sodium and potassium metabolism. Both Na and K belong to the first column of the periodic system and they are entangled in the control of the cell membrane ionic Na and K transport. In our study, the bio entangled K/Na ratio stays constant over the linear (adequate) part of the sigmoid saturation curve in women but progressively increases in men. We already know that the increased intake of potassium suppresses the appearance of hypertension induced by the increased sodium dietary exposure [28]. Apparently, being a man carries the inherited risk towards development of the hypertension.

Today, an average adult American men and women aged 19–71+ years are consuming 2.83–3.34 and 2.21–2.43 mg K per day, respectively. At the same time, the average daily consumption of sodium for the same age group population was 2.43–5.64 for men and 1.96–3.41 mg per day for women [29]. It is reasonable to assume that such an amount of potassium and sodium in the diet is adequately represented in their hair median concentration values for both men and women. In comparison, the estimated daily intake of K and Na in the white Caucasian Croatian population is considerably higher than that of the USA population [30]. However, in comparison, the US medians for a Na and K would be only lower on the common linear segment of the sigmoid saturation curve, than that for the Croatian population [15]. Thus, since the dietary intakes of K and Na are indeed represented as their hair concentration (as they are), then they would both fall well within the adequate range of their dietary intake. That leads us to the conclusion that there is no need to reduce the current level of sodium in our diet for the general population. The results urged us to provide means for the individual control of Na and K dietary intake to identify the dietary sodium overexposed subjects. Indeed, this study showed, for the first time, that there are apparently healthy subjects having a low sodium (and potassium) nutritional status. Not only their high nutritional status.

We are in no way saying that the excess dietary sodium is not harmful to the human health by inducing the increased blood pressure, especially in the salt-sensitive individuals [31], but our data indicate that there is no reason to reduce current dietary salt intake level an block for the general population [32, 33]. Indeed, such dietary salt reduction is a kind of “One size fit all” philosophy approach and what is certainly not justified.

With regard to the plethora of studies searching to prove the causative effect of the increased dietary salt intake on the cardiovascular system, and hypertension, in particular, we think that the respective researchers fall into the cognitive trap of the doctor Snow’s water-pump handle of the cholera epidemic in London in the nineteenth century [34]. Indeed, bioelements like Na and K, when within the adequate dietary intake range, are not foreign substances to our bodies, like vibrio cholera, which is a xenobiotic bacteria; they are very much our body’s essential constituents. We have discussed the issue about copying the bacteriology solutions to the trace element-specific problems in our article on assessing boron nutritional status, the time when trace element research was borrowing the concepts from the then more advanced microbiology [35].

As a matter of fact, our study does not contradict other studies where hypertension is associated with the increased urinary excretion of sodium after the increased dietary salt intake. Our study indicates that the increased urinary sodium excretion in hypertension, as observed by some researchers, is not the consequence
of the increased dietary salt intake, but the failure of the cell membrane to maintain the Na and K osmotic gradient. Thus, hypertension in either the US or Croatia, is not the cause, but the effect of such an impairment. Indeed, numerous studies indicate that the impaired Na K ATPase cell membrane function may be the principal etiological cause of essential hypertension [36–39]. Our median derivatives bioassay provides a simple mean to identify the subjects at risk in the population, if and when they exceed the here proposed boundaries of the normal hair Na and K concentrations. Apparently, the essential hypertension is the “writing on the wall” that we are just aging, and that the other metabolic weakness should be also considered [40].

Acknowledgements

The initial summary of this study was partly presented at the 2015 Experimental Biology meeting (FASEB J 2015;29:S1). The author would like to thank the English language Prof. Emeritus David F. Marshall for his help with the English language.

A. Appendix

A.1 Hair potassium (H K) and hair sodium (H Na) analysis

A strand of hair 5–7 cm long and weighing less than one gram would be cut with titanium coated scissors over the anatomically well-defined bone prominence at the back of the skull (lat. protuberantia occipitalis externa). The individual hair samples were further minced into strands less than 1 cm long prior to chemical analysis, stirred 10 min in an ethylether/acetone (3:1, w/w), rinsed three times with the deionized H2O (18 MΩ cm), dried at 85℃ for 1 h to constant weight, immersed one hour in 5% EDTA, rinsed again in the deionized H2O, dried at 85℃ for twelve hours, wet digested in HNO3/H2O2 in a plastic tube, sonicated, and microwaved. The digested solutions were quantitatively transferred into 15 ml polypropylene test tubes. The liners and top were rinsed three times with deionized water, and the rinses were transferred into the individual test tubes. These test tubes were filled up to 15 ml with deionized water and thoroughly shaken to mix. The samples were run in NexION 300 + NWR 2013 spectrometer (Perkin Elmer, USA). Graduation of the instrument was carried out with a Perkin Elmer reference solution. We used certified GBW09101 Human Hair Reference Material (Shanghai Institute for Nuclear Research, Academia Sinica, Shanghai 201849, China, to validate the quality of the analytical work.

A.2 Whole blood potassium (WB K) and whole blood sodium (WB Na) analysis

Whole blood was drawn by venipuncture from v. cubiti and collected into green-cup Vacuette collecting tubes (#454082 LotA13030M7m Greineer Bio On International AG Kremsmunster, Austria) which were randomly assigned for the ICP-MS analysis. Whole blood samples of 0.5 ml were digested in a microwave oven with 0.1 ml of HNO3 at 175℃ C. Blood standards were lyophilized Seronorm TM Trace Elements Whole Blood Reference Standards Level 1 (OK 0036, Level 2 (MR 9067), and Level 3 (Ok 0337) for selenium in the whole blood (SERO AS, Billingstad, Norway). Five ml of redistilled H2O
were added to every reference standard and stirred gently at room temperature for two hours to equilibrate. One ml of such equilibrated standard was pipetted in 25 ml quartz glass vial, and dried at 105°C for 24 h. The microwaved samples were dissolved in 5 ml of redistilled H₂O with 0.1 ml of H₂O₂ added.

The detection limits for potassium (K) and sodium (Na) in the hair and whole blood were 0.0105 and 0.00105 μg g⁻¹, respectively. All chemicals were of pro analysis grade (Khimmed Sintez, Moscow, Russia).

B. Appendix

B.1 The median derivatives bioassay (population size, PS = 1.000)

We assessed the nutritional status by analyzing the frequency distribution of hair sodium and potassium and whole blood potassium and sodium with the Median derivatives bioassay. First, we assess the median (M₀) hair and whole blood sodium and potassium concentration of our subject population. By definition, one-half of the studied population was above the median (upward median branch U₀), and the other half was below the median (downward median branch, D₀). Hence, the population size (PS) for M₀ is the sum of the respective upward and downward median branches around the central inflection “hinge” M₀, i.e., PS = U₀ + D₀ = 0.5 + 0.5 = 1.0. Both the respective upward and downward median branches can be further divided in the same “median of median” way into a series of sequential median derivatives (U₀,1,2,3, ... n–1, n and D₀,1,2,3, ... n–1, n). For every 2 median derivative of the population, the actual hair lithium concentration can be identified. Thus, instead of mechanically throwing the preconceived percentile grid upon the observed data, we inferred the median derivative grid out from the data set itself.
C. Appendix

C.1 Potassium hair median derivatives bioassay (MDB) input data

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<th></th>
<th></th>
<th>Median (M₀)</th>
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<td>Women (n = 734)</td>
<td>73.7 μg·g⁻¹·K</td>
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Potassium whole blood median derivatives bioassay input data

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Men: Capital letters (D1 – D6, U1 – U6), Women: small letters (d1 – d6, u1 – u6).

C.2 Hair sodium median derivatives bioassay (MDB) input data

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<td>Women (n = 734)</td>
<td>254.0 μg·g⁻¹·Na</td>
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### Whole blood sodium median derivatives bioassay (MDB) input data

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MEN: Capital letters (D1 – D6, U1 – U6), Women: small letters (d1 – d6, u1 – u6).

### Author details

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References


Hypertension - An Update


[27] Sanders CL. Radiation and the linear no-threshold Assumption. Heidelberg, Germany: Springer; 2010


[33] Moore L, Singer M, Bradley ML. Low sodium intakes are not associated with lower blood pressure levels among the Framingham offspring study adults. Experimental Biology. 1917;446(6)


Kita S, Iwamoto T. Mechanisms for linking high salt intake to vascular tone: Role of Na(+) pump and Na+/Ca2(+) exchanger coupling. Yakugaku Zasshi. 2010;130:1300-1405
