Aging, Acculturation, Salt Intake, and Hypertension in the Kuna of Panama

Norman K Hollenberg, Gregorino Martinez, Marji McCullough, Terrn Menkmg, Diane Passan, Mack Presto, Alicia Rivera, David Taplin, Maureen Vicaria-Clement

Abstract The indigenous Kuna who live on islands in the Panamanian Caribbean were among the first communities described with little age-related rise in blood pressure or hypertension. Our goals in this study were to ascertain whether isolated island-dwelling Kuna continue to show this pattern, whether migration to Panama City and its environs changed the patterns, and whether the island-dwelling Kuna have maintained their normal blood pressure levels despite partial acculturation, reflected in an increased salt intake. We enrolled 316 Kuna participants who ranged in age from 18 to 82 years. In 50, homogeneity was confirmed by documentation of an O+ blood group. In 92 island dwellers, diastolic hypertension was not identified and blood pressure levels were as low in volunteers over 60 years of age as in those between 20 and 30 years of age. In Panama City, conversely, hypertension prevalence was 10.7% and exceeded 45% in those over 60 years of age (P<0.01), blood pressure levels were higher in the elderly, and there was a statistically significant positive relationship between age and blood pressure (P<0.01). In Kuna Nega, a Panama City suburb designed to maintain a traditional Kuna lifestyle but with access to the city, all findings were intermediate. Sodium intake and excretion assessed in 30 island-dwelling Kuna averaged 135±15 mEq/g creatinine per 24 hours, exceeding substantially other communities free of hypertension and an age-related rise in blood pressure. Despite partial acculturation, the island-dwelling Kuna Indians are protected from hypertension and thus provide an attractive population for examining alternative mechanisms (Hypertension, 1997;29[part 2]:171-176.)

Key Words sodium potassium magnesium calcium body mass obesity aging

The Kuna Indians who live in the isolated San Blas Island chain off the Caribbean Coast of Panama were among the first communities described in which hypertension is rare.1 In their recent review, James and Baker2 cited 39 such populations in Africa, the Americas, Asia, and the Pacific Region. In many of these communities, the primary evidence that the protective factor is environmental rather than genetic was the blood pressure rise following migration to an urban environment.2-19 Among the many lines of evidence suggesting a role for salt intake in the pathogenesis of hypertension, particularly compelling has been the identification of these isolated communities where salt intake is low, hypertension is rare, and blood pressure does not rise with age. By 1976, Page3 concluded that all low blood pressure populations have a low salt intake as part of their biology and probably as a major causal mechanism and supported that conclusion by citing nine earlier studies. Since that time, a number of confirmatory studies have been reported.8-12 Salt intake in such "protected" communities generally provided less than 40 mEq of sodium per day, and typically much less.

Our goals in this study were to ascertain whether we could confirm the absence of hypertension and age-related rise in blood pressure in isolated island-dwelling Kuna 50 years after the original observation and to extend the observation to blood pressure level in relation to age in Kuna who had moved to Panama City and its environs. Our final goal was to pursue anecdotal suggestions that the island-dwelling Kuna have maintained their benign blood pressure levels despite partial acculturation, reflected in an increased salt intake. Absence of hypertension and an age-related rise in blood pressure despite a substantial level of salt intake would not deny a role for salt but rather would facilitate the exploration of additional responsible mechanisms that are more difficult to identify or assess in the presence of a low-salt intake.

Methods

Subjects

The 316 participants, who ranged in age from 18 to 82 years, were all Kuna Indians by self-identification and community recognition. In 50 of the volunteers, homogeneity was confirmed by the assessment of blood group. All were of blood group O+. The age listed was self-proclaimed but could be confirmed approximately by community records and family relationships.

Three groups of subjects were recruited. The 142 isolated island-dwelling Kuna were recruited and studied in two San Blas islands, Ailigandi and Ticantiki. Each volunteer had lived their entire life on the island with only occasional, brief visits to the city. Another 84 were recruited and studied in Panama City. They were long-term inhabitants of the city enrolled via a community center maintained by the Kuna community in Panama City. The third group of 90, labeled "suburban," live in Kuna Nega in the outskirts of Panama City. Although many Kuna Nega dwellers work in Panama City, they live in a more traditional Kuna community and maintain a more traditional lifestyle than is possible in urban Panama City.

Informed consent was obtained from each participant after a detailed description of the protocol. The protocols and approach to informed consent were approved by the Panamanian Ministry of Health, the Sistemas Integrado de Salud, San Blas, Panama, by each community's "congresso" (a local, grassroots participatory governing body), and by the Human Subjects Committee of the Brigham and Women's Hospital, Harvard Medical School.
Protocols

In all subjects, blood pressure was measured by the auscultatory method in either arm after several minutes of quiet sitting. Three measurements were made, and the average was used. Measurements in the three locations were made by one physician and one nurse during the first stage of this study, at a time when the declared emphasis involved nutrition and no hypotheses involving migration and blood pressure regulation had been raised.

In 50 island-dwelling Kuna, an additional protocol was designed to assess dietary intake of protein, sodium, potassium, magnesium, calcium, fiber, and calories. A simultaneous 24-hour urine collection was made for measurement of the excretion of the same electrolytes, urea, and creatinine. For several reasons, the 50 volunteers who were selected for this element in the study belonged to nine households, and all members of each household were studied simultaneously. The Kuna are a matriarchal society, and the matriarch helped with enrollment and quality control on urine collections. An ice-filled beer cooler was placed in each home for the 24 hours of the study to hold the containers used to collect the 24-hour urine sample and as a highly visible reminder of participation. The reinforcement provided by the simultaneous involvement of all members of the household and the high visibility of the instrument employed for the collection we thought might facilitate accurate collections. Each household heard detailed instructions on collection of 24-hour urine samples both during the enrollment stage and during the stage when informed consent was obtained, and finally immediately prior to the active study.

Urine collections were measured, fractionated into aliquots, and stored in a dedicated, diesel-powered freezer. On the same day, a blood sample was drawn to measure serum electrolytes, urea, and creatinine. Blood and urine samples were transferred to insulated containers containing dry ice for transport by charter flight to Panama City and then to Boston for assay. Thermometers designed to record the highest temperature experienced during storage were employed to ensure sample stability during storage and shipment.

Measurements of plasma and urine electrolytes, urea, and creatinine were made by autoanalyzer. The normative values employed reflect the Boston-based laboratories' experience with assay of these analytes. Blood pressure was measured by the auscultatory method in each arm after several minutes of quiet sitting. The Island-dwelling Kuna showed neither an age-related rise in systolic, diastolic (Fig 1), or mean arterial pressure as a function of location, age, and gender,

Statistics

Mean values have been presented with the standard error of the mean as the index of dispersion. Renal excretion of electrolytes and urea was normalized to urine creatinine to adjust for incomplete collections. That adjustment also served to adjust for body size, as creatinine excretion varies with body size. Assessment of blood pressure as a function of location, age, and gender was made by ANOVA. Renal excretion of electrolytes was also examined by $\chi^2$ and by Spearman's nonparametric correlation, to examine interaction and differences based on age and gender.

Results

The island-dwelling Kuna showed neither an age-related rise in systolic, diastolic (Fig 1), nor mean arterial pressure (Table 1). By JNCV criteria, stage 1 hypertension was identified in only two subjects (2.2%) and reflected minimal criteria in each, with a systolic pressure of 140 mm Hg and a diastolic below 85 mm Hg. Body mass index (BMI) averaged 22.5 ± 0.6 kg/m² and did not rise with age.

Conversely, in the Kuna who resided in Panama City, blood pressure rose significantly with age ($P < 0.01$): Fig 1

Fig 1 Relation between age, blood pressure (BP), and hypertension prevalence in three Kuna communities. Kuna Nega is a suburban community, which is inhabited only by Kuna Indians and which allows them to maintain some, but not all, of their island lifestyle. Note that both systolic and diastolic blood pressures rise significantly with age in the Kuna residing in Kuna Nega and Panama City, but not on the isolated island ($P < 0.01$). Hypertension is much more prevalent in both communities than in the island dwellers.
and Table 1), the overall prevalence of hypertension was 10.7% \((P<0.01)\) and was an especially striking 45.1% in those over 60 years of age. Body mass index averaged 23.6±0.5 kg/m\(^2\), significantly more than in the island dwellers \((P<0.01)\). Although BMI did not rise with age, there was a correlation between BMI and blood pressure in the elderly \((r=18; P<0.01)\).

In the Kuna residents of the suburban community of Kuna Nega, all findings were intermediate but resembled urban Panama City more than the isolated islands in overall hypertensive prevalence (9 of 90; 10%), prevalence in those over 60 years of age (35.9%), and rise of average blood pressure with age \((P<0.001)\). Average BMI, on the other hand, was 22.8±0.3 kg/m\(^2\), almost identical to the island dwellers.

Laboratory investigation and information on dietary history to date is available for 50 island-dwelling Kuna. Average serum sodium and potassium concentrations were in the normal range (Table 1), with a serum creatinine concentration at the middle of the normal range and a blood urea nitrogen concentration at the low end of the normal range.

The sodium content of the 24-hour urine collections averaged 135±15 mEq/g creatinine (Table 2) but ranged widely. The data in Fig 2 are presented with the individual values on the ordinate and average values for each of the family households on the abscissa. Average values in individual families ranged from about 70 to about 710 mEq/g creatinine per 24 hours, and there was wide individual variation around each family’s average. Only 5 of 50 participants excreted less than 40 mEq/g creatinine per 24 hours. Neither age nor gender influenced sodium excretion.

The potassium content of the 24-hour urine collections averaged 47±3 mEq/g creatinine per 24 hours (Table 2). Family and individual variations were substantial, but both were smaller than was the case for sodium. As was the case for sodium, the potassium content of the urine was well within the laboratory usual range based on a western urban experience, without adjustment for creatinine excretion (Table 2). The ratio of sodium to potassium excretion averaged 2.87. The calcium content of the 24-hour urine collections averaged 104±9 mg/g creatinine per 24 hours, at the lower end of the expected range (Table 2), and the magnesium content \((63±4 \text{ mg/g creatinine per 24 hours})\) was below the normative range (Table 2).

The excretion of urea, employed as an index of protein intake, averaged 5.3±0.3 g/g creatinine, also below the laboratory usual range (Table 2) or western standards \(^{10}\). Variation in urea excretion \((\text{coefficient of variation of 39.6%) was less than sodium excretion (coefficient of variation of 77.8%).})\)

Dietary history confirmed a substantial sodium intake (Table 3) and suggested a more substantial intake of potassium and magnesium than was revealed by the 24-hour urine samples. Assessment of sodium intake was much more straightforward than potassium or magnesium intake. Table salt is the major source of sodium in the Kuna diet, since most foods consumed in the San Blas are relatively low in sodium. Of the 31 of 50 subjects who added salt to their food, the average amount consumed was 2.6 teaspoons (554 mg or 240 mEq), with a range of 0.2 to 6 teaspoons per day. Of those salt users, added salt contributed 75% to their overall sodium intake. In comparison with typical US patterns of intake, fat and protein ingestion were low and carbohydrate and fiber intake were high. There was no ethanol use recorded.

**Discussion**

In their monograph on ethnobotany, Ballck and Cox\(^{20}\) provided a useful definition of “indigenous peoples” as people who “... follow traditional non-industrial lifestyles in areas that they have occupied for generations.” In all earlier studies on blood pressure in indigenous peoples that identified a role for low-salt intake, the crucial step involved acculturation due to migration. In this study of an indigenous people, among the first identified for their special blood pressure profile,\(^1\) it appears that partial acculturation has occurred without migration. Salt use has become substantial in the areas that they have occupied for generations, and yet hypertension is rare and blood pressure does not rise with age.

This study answered the three questions raised. First, the rarity of hypertension and absence of an age-related rise in blood pressure was confirmed in isolated, island-dwelling Kuna.\(^1\) Second, the absent age-related rise in blood pressure and the low prevalence of hypertension could be attributed to environmental rather than familial

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**Table 1.** Kuna: Location, Demographics, and Blood Pressure by Age Group

<table>
<thead>
<tr>
<th></th>
<th>Island</th>
<th>Kuna Nega</th>
<th>Panama City</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;40 y</td>
<td>41-60 y</td>
<td>&gt;60 y</td>
</tr>
<tr>
<td>Age, y</td>
<td>29±2</td>
<td>50±1</td>
<td>71±2</td>
</tr>
<tr>
<td>BMI, kg/m(^2)</td>
<td>23.8±1</td>
<td>22.4±0.5</td>
<td>21.9±0.9</td>
</tr>
<tr>
<td>MBP, mm Hg</td>
<td>82±12</td>
<td>80±12</td>
<td>82±14</td>
</tr>
</tbody>
</table>

BMI indicates body mass index, MBP, mean blood pressure 

\(^{*P<0.01}\) (correlation with age)

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**Table 2.** Chemical Findings in Serum and Urine in Island-Dwelling Kuna

<table>
<thead>
<tr>
<th></th>
<th>Na, mEq/L</th>
<th>K, mEq/L</th>
<th>Urea, mg/dL</th>
<th>Creatinine, mg/dL</th>
<th>Volume, mL</th>
<th>Na, mEq/g Creatinine</th>
<th>K, mEq/g Creatinine</th>
<th>Mg, mg/g Creatinine</th>
<th>Ca, mg/g Creatinine</th>
<th>Urea, g/g Creatinine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study results</td>
<td>138±0.2</td>
<td>3.9±0.04</td>
<td>99±0.4</td>
<td>1.1±0.02</td>
<td>1320±84</td>
<td>135±15</td>
<td>47±3</td>
<td>83±4</td>
<td>104±9</td>
<td>5±3±0.3</td>
</tr>
<tr>
<td>Lab usual Range</td>
<td>136-142</td>
<td>3.5-5.0</td>
<td>9-25</td>
<td>0-8-13</td>
<td></td>
<td>75-200</td>
<td>40-80*</td>
<td>120-245*</td>
<td>50-400*</td>
<td>6-0-17.0*</td>
</tr>
</tbody>
</table>

\(^{*}\)Not normalized to gram creatinine
or genetic factors, as blood pressure rose with age and hypertension prevalence rose strikingly among Kuna who had moved to Panama City. This observation confirms a range of studies on the migration experience and blood pressure. Indeed, there appear to be no reported exceptions in which migration to an urban setting did not lead to changes in the blood pressure pattern. The third observation, involving sodium intake and excretion, is novel. The source of the salt ingested involves trade with fishermen, largely from neighboring Colombia. Shellfish are traded for bags of table salt, which is added to the food, especially the stew, according to individual taste. The stew is still prepared in the traditional manner and contains neither salt nor salty ingredients. Lore has it that the most dramatic changes in lifestyle have occurred in the past two decades.

There are several limitations of this study. An objective measurement was not employed for the blood pressure measurement. We think it unlikely that bias can account for the differences in hypertension prevalence in the three communities. The data were collected as part of a program that was designed to examine nutrition, and the emphasis was on the body height and weight measurement, rather than blood pressure or age. Indeed, the absence of hypertension among Kuna in the islands is widely recognized and shapes Panamanian health policy. The blood pressure elevation in Panama City was routinely confirmable, and the striking correlation with age and concordance between the findings in Kuna Nega, where no prior hypothesis could have existed, and Panama City are supportive. Future studies will require an objective, bias-free blood pressure measurement, however, as these arguments no longer apply with the analysis of the data, but even these can be a problem. The 24-hour urine collections are also suspect. Despite substantial effort, more than 50% of the 24-hour urine collections contained less than 1000 mg of creatinine and probably reflect incomplete collections. Al-though normalization to creatinine content provides a reasonable estimate, there are limitations. One is more likely to underestimate than overestimate content. Thus, we can have far more confidence in the likelihood that the sodium intake is high than we can in values characterizing potassium, magnesium, and calcium intake and excretion. In their case, the dietary assessment may have provided a more accurate measure of intake than did the 24-hour urine collections, although there were several limitations with this as well. Imputation of the potassium and magnesium content of several food items was necessary and may have resulted in overestimation or underestimation. In addition, recipe analysis involved several assumptions, including consumption of equal portions of all stew ingredients by all household members and assumptions about the nutrient density of the stew. It is exceedingly unlikely that the very low urea content, on the other hand, can be attributed to

### Table 3. Kuna Nutrient Intake in San Blas Islands

<table>
<thead>
<tr>
<th>Index</th>
<th>Mean±SEM*</th>
<th>Average US Intake (Mean±SEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilocalories</td>
<td>2221±117</td>
<td>1914±10</td>
</tr>
<tr>
<td>Protein, g</td>
<td>67±3</td>
<td>75±3±0.5</td>
</tr>
<tr>
<td>Protein, %</td>
<td>12±0.3</td>
<td>15.7</td>
</tr>
<tr>
<td>Total fat, g</td>
<td>5±0.3</td>
<td>7±6±0.5</td>
</tr>
<tr>
<td>Fat, %</td>
<td>23±0.3</td>
<td>36±9</td>
</tr>
<tr>
<td>Cholesterol, g</td>
<td>39±23</td>
<td>209±1.1</td>
</tr>
<tr>
<td>Cholesterol, %</td>
<td>7±0.3</td>
<td>44</td>
</tr>
<tr>
<td>Dietary fiber, g</td>
<td>2±0.3</td>
<td>15±9±0.1</td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>517±50</td>
<td>736±6.4</td>
</tr>
<tr>
<td>Potassium, mEq</td>
<td>98±6.9</td>
<td>62±0.4</td>
</tr>
<tr>
<td>Magnesium, mg</td>
<td>368±22</td>
<td>296±2.8</td>
</tr>
<tr>
<td>Sodium, mEq</td>
<td>210±22</td>
<td>121±5.7</td>
</tr>
</tbody>
</table>

*n=50
*Based on single 24-hour recall

All averages calculated from NHANES II, except magnesium and fiber, which were calculated using advanced data from NHANES III (male and female adults, all income levels).

![Graph](http://hyper.ahajournals.org/)

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**Fig 2.** Relation between average excretion of sodium, potassium, and urea in nine island-dwelling families (abscissa) versus the individual values in each family (ordinate). Salt intake and excretion were substantial in island-dwelling Kuna who are protected from hypertension and age-related rise in blood pressure. Only 5 of the 50 subjects showed a sodium excretion level similar to those reported for other isolated, normotensive cultures. Note that potassium and urea excretions vary less in families and in individuals. Potassium excretion differs little from that in western urban cultures, but urea excretion is well below a typical urban western sample, suggesting a sharply lower protein intake.
anything other than a rather low protein intake, as the values were very low.

Sodium intake and excretion have been the subject of substantial investigation in many communities, including a number of those that share characteristics of the Kuna.\textsuperscript{3,6-12} Without exception, in such communities studied hitherto the sodium intake and the sodium content of the urine has been very low, and where migration has occurred, one of the elements in acculturation has been an increase in sodium intake and excretion.\textsuperscript{3,6-12} Despite the limitations of this study, it is clear that these factors are not operative in the Kuna. This is not to deny the importance of salt intake, but rather to point out that even those convinced that salt intake is important recognize that additional factors are likely to play a role. Teasing out such factors in populations in which a large change in salt intake follows migration is difficult because the signal-to-noise ratio is unfavorable. The Kuna, therefore, provide a special opportunity for exploring additional factors that contribute.

Diet pattern has provided an array of alternatives beyond sodium intake. The vegetarian diet\textsuperscript{22-26} has been especially consistent in its association with lower blood pressure, and the indigenous communities in which hypertension is rare typically ingest a diet that resembles far more a vegetarian than a western, urban diet. The low protein intake and high fiber content of the Kuna diet documented in this study certainly are consistent. Vegetarians in industrial countries have lower blood pressures and less hypertension than comparable neighbors who are not vegetarians,\textsuperscript{26} and intake of animal products tends to correlate directly with blood pressure level.\textsuperscript{25} Increasing the protein content of a diet with protein supplements did not affect blood pressure,\textsuperscript{27-29} but the protein supplement may not match the shift in proteins ingested with acculturation. Vegetarian diets are generally rich in potassium and magnesium, and there is substantial epidemiological evidence of an inverse relationship between their respective intake and blood pressure.\textsuperscript{30-33} Their contribution to maintaining normal blood pressure remains controversial.\textsuperscript{34} The limited ability of the current 24-hour urine collection to estimate potassium, magnesium, or calcium ingestion was discussed above, but that limitation does not extend to the Na:K ratio, thought by some to be protective.\textsuperscript{11} The Na:K ratio in this study, 2.87, is closer to typical urban than typical indigenous levels.\textsuperscript{11}

Other candidates for the environmental contribution include alcohol use, obesity, physical inactivity, and psychosocial stress.\textsuperscript{16} Alcohol use is uncommon in island-dwelling Kuna, with the exception of a quarterly festival, the “Cheche.” The Kuna living in Panama City on average had a BMI that was significantly higher than on the island, but obesity per se was rare, and a weak correlation was found between BMI and blood pressure. BMI did not increase with age in any of the communities. Whether a reduction in physical activity, alcohol use, or increased psychosocial stress contributes demands further investigation. As pointed out in a recent review,\textsuperscript{16} “Psychosocial stress has the credentials for the missing factor, although it remains an elusive quantity to measure.” The measurement will not be less difficult in a different culture.

The Kuna reside in the San Blas Islands, an archipelago off the Caribbean coast of Panama comprising about 360 islands, of which 66 are populated by the Kuna.\textsuperscript{35} They have lived on these islands for centuries,\textsuperscript{36} but their origin is not completely understood. Recent studies have revealed a remarkably low level of mitochondrial gene diversity, suggesting that there has been remarkably little genetic admixture.\textsuperscript{36} Both of these features could be helpful in attempts to dissect the pathogenesis of hypertension.

Substantial evidence favors a complex series of factors in blood pressure homeostasis. The fact that the Kuna are generally normotensive and lack the usual age-related rise in blood pressure while residing on the islands, despite a substantial salt intake, provides an opportunity to examine alternative factors that might make a contribution. The Kuna provide an attractive model for another reason: between the island-dwelling Kuna who are protected and the Kuna who have migrated to Panama City, there are Kuna residing in suburban communities who maintain some but not all of their traditional lifestyle. In this preliminary study, for example, they had not gained weight, and yet blood pressure rose with age and hypertension prevalence almost matched that in Panama City. This group should provide an attractive opportunity for future investigation.

Acknowledgments

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References

1 Kean BH. The blood pressure of the Kuna Indians. Am J Trop Med Hyg 1944;24:341-343
3 Poulter NR, Mbandelere RS, Deerenberg H. The influence of the otolith on blood pressure. J Hypertens 1984;2:43-54
13 He J, Klager MJ, Whelton PK, Chen JY, Mo JP, Quan MC, Mo JP, Quan MC, Mo PS, He QQ. Migration, blood pressure pattern and...
hypertension the Yi migrant study Am J Epidemiol 1991,134 1085-1101
14 Hopper JL, Macaskill OT, Powles JW, Zienas D Pedigree analysis of blood pressure in subjects from rural Greece and relatives who migrated to Melbourne, Australia Genet Epidemiol 1992,9 225-238
15 Beaglehole R Blood pressure in the South Pacific: the impact of social change Ethn Dis 1992,2 55-62
16 Cooper R, Rotimi C Hypertension in populations of West African origin: is there a genetic predisposition? J Hypertens 1994, 12 215-227
18 Blackburn GL, Bittman BR, Mann BS, Schlam HT, Smith MF Nutritional and metabolic assessment of the hospitalized patient J Parent Ent Nutr 1977,1 15
21 Birkett NJ Potential problems with the random-zero sphygmomanometer Hypertension 1994,23 254-257
25 Rouse IL, Armstrong HK, Balin LJ The relationship of blood pressure to diet and lifestyle in two religious populations J Hypertens 1984,1 65-71
26 Sacks FM, Kass EH Low blood pressure in vegetarians effects of specific foods and nutrients Am J Clin Nutr 1988,48 795-800
28 Sacks FM, Wood PG, Kass EH Stability of blood pressure in vegetarians receiving dietary protein supplements Hypertension 1984,6 199-201
29 Prescott SL, Jenner UA, Bentin LJ, Margetts BM, Vandongen R A randomized controlled trial of the effect on blood pressure of dietary non-meat protein in normotensive omnivores Clin Sci 1988,1 665-672
31 Kesteloot H, Joossens JV Relationship of dietary sodium, potassium, calcium, and magnesium with blood pressure Belgian interuniversity research on nutrition and health Hypertension 1988,12 294-309
32 Intersalt Cooperative Research Group INTERSALT an international study of electrolyte excretion and blood pressure—results for 24-hour urinary sodium and potassium excretion Br Med J 1988,297 319-328
34 The Trials of Hypertension, Prevention Collaborative Research Group The effects of nonpharmacologic interventions on blood pressure of persons with high normal levels results of the trials of hypertension prevention—phase I JAMA 1992,267 1213-1220
36 Batista O, Kolman CJ, Berrinham E Mitochondrial DNA diversity in the Kuna Amerindians of Panama Hum Mol Genet 1995,4 921-929
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