

# Dietary Potassium Intake and Renal Handling, and Their Impact on the Cardiovascular Health of Normotensive Afro-Caribbeans

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## ABSTRACT

**Objective:** Recent nutritional profiles of dietary intake have indicated a shift from the ancient diet to the Western diet. The ancient diet provided high potassium and low sodium intake, which in turn led to sodium conservation and potassium excretion. This change in the dietary intake is expected to affect potassium and sodium handling in the kidneys. Numerous studies have been done to emphasize the importance of sodium handling by the kidneys and its impact on cardiovascular health. This study will investigate potassium intake and handling, and its impact on the cardiovascular health of a sample of normotensive Afro-Caribbeans by the possible modulation of the renin angiotensin aldosterone system (RAAS).

**Methods:** A sample of 51 normotensive Afro-Caribbean participants was recruited for the study. Participants were observed over a two-day period in which they were given a 24-hour ambulatory blood pressure monitor and a container to collect blood pressure data and a 24-hour urine sample. Anthropometric measurements were noted. Urinary electrolytes and supine plasma renin activity (PRA) were determined from the 24-hour urine collection and a blood sample. Dietary potassium intake was estimated based on dietary intake observations, and calculated based on the urinary potassium excretion. SPSS version 19 was used to analyse the data to make inferences.

**Results:** The daily potassium intake was observed to be 2.95 g/day and measured intake from the urinary potassium was between 4.95 and 7.32 g/day. Urinary potassium excretion was 3.66 ( $\pm$  1.40) g/day. The urinary potassium excretion in the Afro-Caribbean sample in Barbados was higher than the other population samples. The averaged PRA of the participants (supine) was 0.778 ( $\pm$  1.072) ng/mL/hour. The averaged nocturnal systolic blood pressure dip of the participants was 5.97 ( $\pm$  4.324) %. There was no significant correlation between urinary potassium excretion, blood pressure, nocturnal systolic blood pressure dip and PRA.

**Conclusions:** The Afro-Caribbean sample has an inadequate daily potassium intake based on the observed intake and recommended values, with a high urinary excretion of the electrolyte compared to other values in the literature. This high potassium excretion could have been partly due to low plasma renin activity levels in the study participants. As a possible consequence, an increase in the nocturnal peripheral resistance is a likely cause for the diminished systolic dip. The lack of correlations between dietary potassium excretion and the blood pressure parameters does not allow any firm inference of the electrolyte's handling and its impact on cardiovascular health in the normotensive Afro-Caribbean participants. However, further research is needed to get a more accurate daily potassium intake value, and a more statistically robust sample to assess whether potassium handling and blood pressure would be affected by a change in potassium intake.

**Keywords:** Afro-Caribbean, dietary, plasma renin activity, potassium handling, potassium intake, potassium urinary excretion, sodium urinary excretion

## Ingesta Dietética de Potasio y Manejo Renal, y Su Impacto en la Salud Cardiovascular de los Normotensos Afrocaribeños

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### RESUMEN

**Objetivo:** Los perfiles nutricionales recientes de ingesta dietética han indicado un cambio de la dieta antigua a la dieta occidental. La dieta antigua ofrecía un consumo alto de potasio frente a un consumo bajo de sodio, lo que a su vez llevaba a la conservación del sodio y a la excreción del potasio. Se espera que este cambio en la ingesta dietética afecte el manejo del potasio y el sodio en los riñones. Se han realizado numerosos estudios con el fin de enfatizar la importancia del manejo del sodio por los riñones y su impacto en la salud cardiovascular. Este estudio investigará la ingesta y manejo del potasio, y su impacto en la salud cardiovascular de una muestra de normotensos afrocaribeños mediante la posible modulación del sistema renina-angiotensina-aldosterona (SRAA).

**Métodos:** Una muestra de 51 participantes normotensos afrocaribeños fue reclutada para el estudio. Los participantes fueron puestos bajo observación por un período de dos días, en los que recibieron un monitor ambulatorio para registrar la presión arterial por 24 horas, y un recipiente para recoger los datos de la presión arterial, y una muestra de orina de 24 horas. Se observaron las mediciones antropométricas. Los electrolitos urinarios y la actividad de renina plasmática (ARP) en posición supina, se determinaron a partir de la orina de 24 horas y una muestra de sangre. La ingesta dietética de potasio fue estimada en base a las observaciones hechas de la ingesta dietética, y se calculó a partir de la excreción del potasio urinario. La versión 19 del SPSS fue utilizada para analizar los datos y hacer inferencias.

**Resultados:** Se observó una ingestión diaria de potasio de 2.95 g/día, y la ingestión medida a partir del potasio urinario estuvo entre 4.95 y 7.32 g/día. La excreción del potasio urinario fue 3.66 ( $\pm$  1.40) g/día. La excreción del potasio urinario en la muestra afrocaribeña en Barbados fue mayor que en las otras poblaciones. La actividad ARP promedio (supina) de los participantes fue 0.778 ( $\pm$  1.072) ng/mL/hora. La caída nocturna promedio de la presión arterial sistólica de los participantes fue ( $\pm$  4.324) 5.97%. No hubo ninguna correlación significativa entre la excreción del potasio urinario, la presión arterial, la caída nocturna de la presión arterial sistólica, y la actividad ARP.

**Conclusiones:** Partiendo de la base del consumo observado y los valores recomendados, la muestra afrocaribeña presenta una ingesta diaria inadecuada de potasio, con una alta excreción urinaria de electrólito, en comparación con otros valores en la literatura. Esta elevada excreción de potasio podría haberse debido en parte a niveles bajos de actividad de renina plasmática en los participantes del estudio. Una posible consecuencia es el aumento de la resistencia periférica nocturna como causa probable del descenso sistólico. La falta de correlación entre los parámetros de la presión arterial y la excreción de potasio dietético no permite ninguna inferencia sólida del manejo del electrólito y su impacto sobre la salud cardiovascular en los normotensos afrocaribeños participantes. Sin embargo, es necesario investigar más a fin de obtener un valor más exacto de la ingesta diaria de potasio y una muestra estadísticamente más sólida para evaluar si el manejo del potasio y la presión arterial podrían ser afectados por un cambio en la ingesta de potasio.

**Palabras claves:** Afrocaribeño, dietético, actividad de renina plasmática, manejo del potasio, ingesta de potasio, excreción urinaria de potasio, excreción urinaria de sodio

West Indian Med J 2014; 63 (1): 14

### INTRODUCTION

Throughout the years, the ancient diet evolved into a modern Western diet (1–3). The human kidneys are tailored to the ancient diet, which provided a high potassium and low sodium intake, which in turn leads to sodium conservation and potassium excretion (1–3). A decrease in fruits and vegetable intake coupled with an increase of processed foods and grains intake has completely shifted the ratio of dietary sodium and potassium. With the modern Western diet and a lack of renal adaptation, there is ineffective potassium conservation – major losses through renal and fecal route – leading to the deficit of potassium in the body. This in turn enhances the retention of sodium

by the kidneys (1, 2). With an excess of sodium in the body, the extracellular fluid volume expands, leading to the release of digitalis-like factors affecting the sodium-potassium ATPase. Hypertensive risks are then increased due to an increased peripheral vascular resistance secondary to a vascular smooth-muscle cell contraction triggered by both the excess of cellular sodium and the deficit of cellular potassium (1, 2).

A broad body of evidence demonstrates that potassium intake negatively correlates with elevated blood pressure, the main risk factor for cardiovascular disease (1–4). However, the level of the correlation relies on various factors such as salt-sensitivity, determined by genetic factors, race/ethnicity,

age, body mass, diet and associated disease states (4). Afro-Caribbeans have been identified as a salt-sensitive population (4–7), with higher urinary potassium excretion than whites (5, 6). In addition, compared to whites, blacks have a higher prevalence of low-renin and salt-sensitive hypertension (5, 7) and a lower potassium intake (1). The potential causes include differences in the intra-renal renin angiotensin aldosterone system (RAAS), in the medullar thick ascending limb, urinary sodium and potassium excretions and the interaction of the proximal sodium reabsorption and aldosterone production (5). A relationship between angiotensin and hypertension has been found, and is affected by dietary intakes of sodium and potassium, as determined from excretion rates, coupled to the plasma aldosterone in blacks. Aldosterone production is suppressed by greater sodium reabsorption in the more proximal nephron region (5).

There has been growing interest concerning dietary potassium and cardiovascular risks in the Afro-Caribbean population. Indeed, an increase in dietary potassium has been shown to abolish sodium sensitivity in both normotensive and hypertensive subjects (1). However, no data have been found on dietary potassium intake in the Afro-Caribbean population, nor tabulated against urinary potassium excretion values. This study investigates the observed usual dietary potassium intake of Barbadians and its correlation with their urinary potassium excretion, which will help to understand the handling of potassium in the Afro-Caribbean population and potentially detect any differences compared with persons of European or Asian descent. The outcome of the investigation will therefore add to the volume of information published in the Caribbean on potassium excretion, and whether renin status, low plasma renin activity (PRA) effecting salt sensitivity, affects potassium handling. The impact of potassium excretion on systolic blood pressure will also be assessed to investigate any potential correlation with renal potassium handling and cardiovascular disease.

## SUBJECTS AND METHODS

The study was approved by the Institutional Review Board (IRB) of The University of the West Indies, Barbados, and the

Ministry of Health, Barbados. A sample of 51 healthy participants of Afro-Caribbean origin was recruited for the study from The University of the West Indies' Health Services Clinic and the staff clinic at the Hilton Barbados. The exclusion criteria included alcohol intake greater than 14 units per week for women, 21 units per week for males (1 unit = 8 g of alcohol), recreational drug use, smokers (greater than one year), diabetics (diagnosed or on fasting blood glucose), hypertensive patients on medication (JNC pre-hypertension was acceptable), clinically evident vascular disease, and participants with a body mass index (BMI) less than 18 kg/m<sup>2</sup> or greater than 36 kg/m<sup>2</sup>.

In total, 26 females and 25 males aged between 18 and 55 years old participated in the study. Subjects were asked to attend the department on two separate occasions. Upon the first visit, participants were provided with a blood pressure monitor and a container to collect a 24-hour urine sample. A supine blood sample was taken to determine the PRA levels. During the second visit, measurements of height, weight and waist circumference were noted. Also, blood pressure monitors as well as urine samples were returned.

Participants were instructed to initiate urine collection after the first void in the morning period. All volumes of urine and blood samples were recorded. Samples were submitted to the Hypertension and Vascular Disease Center, Wake Forest University Health Sciences for analysis of the PRA in the plasma and electrolytes in the urine.

Dietary potassium intake was thus estimated with the measured urinary potassium excretion. As shown by Turban *et al*, black participants excrete 50 to 74% of dietary potassium in their urine (7). In addition to the urinary potassium, observations of daily dietary choices among staff and students and food menus were made at the Cave Hill Campus of The University of the West Indies in order to estimate the daily dietary potassium intake. The observed usual intake was validated by the data published by Sharma *et al* (8) in the population-based, case-control, Barbados National Cancer Study (BNCS).

SPSS version 19 was used to analyse the data to make inferences. Descriptive data were reported by means ( $\pm$  SD). Pearson's regression analysis was used to identify significant correlations of study variables at the 95% confidence level

Table 1: Participants' descriptive statistics

	n	Minimum	Maximum	Mean	Standard deviation
Body mass index, kg/m <sup>2</sup>	51	17.0	34.0	25.27	4.01
Age, years	51	18	55	35.75	8.74
Waist circumference, cm	51	74	133	99.94	11.83
Supine PRA, ng/ml/hr	51	0.00	7.30	0.778	1.072
ABPM sys BP, mmHg	41	97	150	117.66	12.02
ABPM dias BP, mmHg	41	63	97	74.10	7.85
ABPM sys BP Dip, %	41	-6.4	15.0	5.97	4.32
Heart rate, bpm	51	–	–	76.41	7.03

PRA: plasma renin activity, ABPM: ambulatory blood pressure monitoring, sys: systolic, dias: diastolic, BP: blood pressure, bpm: beats per minute

after verifying if the data were normally distributed by frequency distribution.

## RESULTS

Fifty-one Afro-Caribbean persons participated in the study. As seen in Table 1, the average age and BMI are 36 ( $\pm 9$ ) years and 25.3 ( $\pm 4.0$ ) kg/m<sup>2</sup>, respectively. The average supine PRA of the participants was 0.778 ( $\pm 1.072$ ) ng/mL/hour.

Dietary potassium intake of the targeted population was assessed in two ways. First, based on observations made at The University of West Indies, Cave Hill Campus, daily dietary potassium intake was estimated to be 2.95 g/day. The observed usual intake was validated with the results of the Barbados National Cancer Study, led by Sharma *et al* (8). Secondly, based on the urine samples collected, the mean measured daily potassium excretion was found to be 65.61 ( $\pm 25.06$ ) mmol/L or 2.56 ( $\pm 0.98$ ) g/L. Using the daily urine output volumes of the participants, the average daily urinary potassium excretion is 3.66 ( $\pm 1.40$ ) g. The measured daily potassium intake was also determined based on reports that blacks excrete 50 to 74% of dietary potassium in their urine (7). Thus, the measured daily potassium intake ranges between 4.95 and 7.32 g/day.

Table 2: Mean values of urinary sodium, potassium and creatinine excretion in Brazil, Canada, Japan, India, United Kingdom (UK) and Barbados

Country – year	Urinary sodium mmol/L	Urinary potassium mmol/L	Urinary Na:K	Urinary creatinine mg/dL
Brazil – 2012	110.0	31.0	–	70.8
Canada – 2011	207.4	56.2	–	–
Japan – 2001	179.0	52.0	–	–
India – 1988	160.6	47.4	3.51	11.6
UK – 1988	153.1	63.0	2.59	124.7
Barbados – 2012	174.1	65.6	2.65	288.0

K: potassium, Na: sodium

Table 2 tabulates measured urinary electrolytes – sodium, potassium, sodium potassium ratio and creatinine – excretion in Brazil (9), Canada (10), Japan (11), India (12) and the United Kingdom [UK] (12), compared to the data collected from the Afro-Caribbean sample in Barbados. The results suggest that the sample of Barbadians have the highest urinary excretion of potassium and creatinine compared to the other groups outside of the Caribbean.

Table 3 displays the correlation between 24-hour urinary potassium excretion and urinary sodium and creatinine excretion, BMI, systolic and diastolic blood pressure, systolic blood pressure dip and PRA. Only urinary sodium, potassium and creatinine excretions showed statistically significant positive correlations. Interestingly, all other variables showed no significant correlation. Correlations were also investigated with the ratio of the 24-hour urinary sodium and potassium excretion values (Na/K). The only significant correlations with the urinary Na/K ratio were found with urinary creatinine excretion and waist circumference.

## DISCUSSION

On average, the Afro-Caribbean participants were borderline overweight, as evidenced by a mean BMI and waist circumference of 24.5 kg/m<sup>2</sup> and 102.1 cm for women and of 26.1 kg/m<sup>2</sup> and 97.7 cm for men. As per the World Heart Federation, being overweight increases the risks of developing hypertension, diabetes and atherosclerosis, which in turn lead to high risk of cardiovascular disease (13). People with a BMI over 25 kg/m<sup>2</sup> are considered overweight; 41.2% of participants had a BMI over 25 kg/m<sup>2</sup>: 38.4% of females and 44.0% of males. Also, women with a waist circumference above 88 cm, and men over 102 cm, have a high risk of developing cardiovascular disease (13). This increased risk of developing cardiovascular disease is present in 80.1% of females and 36.0% of males. According to the 2000 Barbados Food Consumption and Anthropometric Surveys (BFCAS), the prevalence of overweight and obesity among adult Barbadians was

Table 3: Correlation between urinary potassium, sodium and creatinine, ABPM blood pressure, PRA, body mass index and waist circumference

		24-hr K/ mmol/L	24-hr Na/ mmol/L	ABPM dias BP	ABPM sys BP mmHg	Body mass index	Creatinine mol/L	Log supine PRA Assay/ ng/mL/hr	Sys BP dip %	Waist circumference cm
24-hour K mmol/L	Pearson Correlation		0.707**	-0.109	-0.113	-0.066	0.339*	0.043	0.174	-0.226
	Sig. (two-tailed)		0.000	0.498	0.480	0.647	0.015	0.766	0.277	0.111
	n		51	41	41	51	51	51	41	51
24-hour Na mmol/L	Pearson Correlation	0.707**		-0.174	-0.249	0.041	0.289*	-0.034	0.162	-0.055
	Sig. (two-tailed)	0.000		0.278	0.116	0.773	0.040	0.812	0.311	0.700
	n	51		41	41	51	51	51	41	51
24-hr Na:K	Pearson Correlation	-0.614**	-0.020	-0.127	-0.111	0.209	-0.434**	-0.037	-0.099	0.411**
	Sig. (two-tailed)	0.000	0.891	0.430	0.490	0.141	0.001	0.799	0.538	0.003
	n	51	51	41	41	51	51	51	41	51

\*\*Correlation is significant at the 0.01 level (two-tailed). \*Correlation is significant at the 0.05 level (two-tailed).

K: potassium, Na: sodium, ABPM: ambulatory blood pressure monitoring, Sys: systolic, Dias: diastolic, BP: blood pressure, PRA: plasma renin activity

55.8% in men and 63.8% in women (14). This was not consistent with the findings of this study due to the exclusion criteria and the sampling not being conducive to a representative sample of the Barbadian population. Even though dated, the severity of the national statistics and the risk of developing comorbidities such as Type 2 diabetes have been underscored.

Health Canada recommends a daily intake of potassium of 4.7 g (15). As seen in the study, the observed estimated intake was 2.95 g/day and the measured estimated intake was 4.95 to 7.32 g/day. The measured value was calculated based on the study by Turban *et al* stating that blacks excrete 50 to 74% of dietary potassium in their urine (7). Thus, compared to the recommendations, the Afro-Caribbean sample in this study has an insufficient potassium intake when considering the observed potassium intake. However, their intake would surpass the recommended intake value if it is estimated from the measured potassium excretion values. These latter intake values are debatable because individual variation in the percentage of dietary potassium excreted in the urine was high and also, unlike sodium, urinary potassium does not closely reflect potassium intake (7). The main sources of potassium in their diet were eggs, mashed potatoes, fish, chicken, fruits, vegetables, juices and beans. The observed intake accounted for 48.12% of the averaged estimated intake from the urinary potassium (6.13 g/day), and 62.8% of the recommended intake. This can possibly be explained by different suppositions. First, there could have been limitations with the observations of the usual intake. There are reasonable fluctuations between daily meals, and variability between individuals, which makes it hard to develop a typical daily dietary intake. On a minor note, the nutritional value of the items constituting a usual diet was taken from the Canadian Nutrient File (16). There are cultural differences between countries that contribute to different food choices. Thus, further research on the foods' nutritional composition in Barbados and the typical food intake should be done in order to obtain a more reliable value of daily dietary potassium intake.

Based on the observed potassium intake, the percentage of potassium excretion by the Afro-Caribbean sample was in excess of the daily intake. It is also well known that there are disparities with potassium renal handling and excretion among various ethnic groups. Studies have shown that the race difference in potassium excretion represents more than an effect of diet, and that racial differences in food preferences are not sufficient to explain the difference in urinary potassium excretion (5, 17). A substantial body of literature demonstrates that urinary potassium excretion is lower among people of African descent compared to whites. Surprisingly, as seen in Table 2, the sample of Barbadians has the highest potassium excretion, compared to persons from other territories outside of the Caribbean. Further work is needed to demonstrate if Afro-Caribbean Barbadians have a higher level of potassium excretion or if this was inherently related to the study's sample. It has also been shown that people of African descent have higher

sodium retention, causing suppression of renin secretion, and leading to higher risks of hypertension. The averaged supine PRA value from the study's participants was consistent to this inference based on reported values (18, 21). This altered sodium kinetics was demonstrated in normotensive blacks as well (18). Studies also show that a high-sodium diet increases the excretion of potassium by increasing distal sodium delivery. With long-term potassium depletion, the renal sodium pump's activity is stimulated, which in turn promotes sodium retention (1).

Plasma rennin activity is commonly used to measure the overall activity of the RAAS and is a surrogate marker of angiotensin II (4, 19). Having low renin levels is also more common in persons of African descent (20, 21), compared with persons of European descent, independent of age and blood pressure status (21). Although the mechanism is not fully understood, the PRA appears to be lower in blacks due to a lower rate of renin secretion. Another explanation suggests that the lower renin is a consequence of differences in renal sodium handling between blacks and whites (21). As known in the literature, people of African descent have an increased tendency to retain sodium. Thus, sodium balance is maintained by a lower PRA. There has also been evidence that there might be a gene variation in the renal epithelial sodium channel at the molecular level (5). Other studies have investigated this phenomenon in relation to potassium and sodium intakes. Reports indicated that Langford *et al* studied this hypothesis by delivering 80 mmol potassium chloride (KCl)/day to hypertensive blacks and whites. They found that the PRA in treated blacks had a significant increase, whereas it was unchanged in whites (18). This finding suggests that the lower PRA may be partly due to low potassium intake in blacks. More so, the high urinary potassium excretion observed in the Barbadian sample could have been partly due to the low plasma renin activity levels in the study participants. As a possible consequence, an increase in the nocturnal peripheral resistance is a likely cause for the diminished systolic blood pressure dip as reported in the findings. This study was conducted on a normotensive sample of participants with an averaged ambulatory blood pressure monitoring (ABPM) reading of 118/74 mmHg. Nevertheless, the low nocturnal systolic blood pressure dip % in these participants would indicate that there is an increase in nocturnal peripheral resistance which can lead to a non-dipping state, a hallmark feature of the salt sensitive state and a precursor to the development of hypertension. The normotensive state of the participants varies significantly from Langford *et al*'s study and might partially explain the lack of correlation between PRA and potassium excretion. However, it is widely known that individuals with lower PRA values tend to be salt sensitive (4). Logically, for people with low PRA levels, there is the likelihood of high circulating level of aldosterone, which stimulates potassium excretion. This information aligns with our results which show high urinary potassium excretion. Further work would be deemed neces-

sary to assess PRA levels in Afro-Caribbean people and to determine its overall consequence in defining salt sensitivity in persons of African descent and their potassium handling.

The INTERSALT study found a significant positive linear relationship between 24-hour urinary sodium excretion and systolic blood pressure after studying 10 079 men and women aged 20–59 from 32 countries (12). The study also estimated that a decrease of 50 mmol/day in urinary potassium excretion is associated with an increase in systolic pressure of 3.4 mmHg, and diastolic pressure of 1.9 mmHg (1). The urinary Na:K ratio in the INTERSALT study had a significant inverse correlation with blood pressure, which was stronger than either sodium or potassium excretion alone. The current study's urinary Na:K ratio showed a significant inverse correlation with creatinine excretion, and a significant positive correlation with waist circumference. Prior mention was made that 80.1% of females compared to 36.0% of males have a waist circumference suggesting increased risk of developing cardiovascular disease. Interestingly, when using BMI, only 38.4% of female participants had increased risks related to a BMI over 25 kg/m<sup>2</sup>. No significant correlation was found between BMI and urinary electrolytes. It enforces the growing evidence that waist circumference is the more validated anthropometric measure for assessing associated disease risk. Also, a meta-analysis of 33 randomized trials concluded that supplementing potassium intake with  $\geq 60$  mmol/day in normotensive participants led to a reduction of systolic and diastolic pressure of 1.8 and 1.0 mmHg, respectively. These effects were greater in trials in which over 80% of the subjects were black (1). Those studies observed a negative correlation between potassium and blood pressure, which differs from this study's findings which addressed urinary potassium. As previously mentioned, it might be due to the fact that the original potassium excretion values were considered, without adjustment to inter-person variability in PRA or potassium handling. Other studies have highlighted some controversy on potassium handling and cardiovascular health. Geleijnse *et al* did not observe an association between potassium intake and coronary events (22). They recommended conducting randomized trials and prospective population-based studies, which should be strongly considered for the Afro-Caribbean ethnic group.

Stronger results and interpretation could have been produced with a more statistically robust sample size to investigate the relationships between variables analysed in this study. This study was exploratory and therefore, can be used to develop a randomized population based study to assess the same study parameters. Also, a more standardized approach to record 24-hour dietary intake *via* a 24-hour recall and food frequency questionnaire could have improved observations for the daily potassium intake. Besides, as per Tayo *et al*, electrolyte excretions are more strongly associated with the body weight than with BMI (6). Another recommendation would be to conduct an interventional study on whether potassium handling and blood pressure would be affected by a short-term or long-

term change in sodium or potassium intake by Afro-Caribbeans. The Afro-Caribbean population might need different recommended intakes for both dietary potassium and sodium.

## ACKNOWLEDGEMENTS

We thank Dr KB Brosnihan, Director of the Peptide Core at the Hypertension and Vascular Research Center and Professor Carlos Ferrario, Professor General Surgery, Internal Medicine/Nephrology, Physiology and Pharmacology at the Wake Forest School of Medicine for their valuable assistance in the processing of the samples.

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