Appetite 52 (2009) 609–613

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

Salt taste sensitivity threshold and exercise-induced hypertension

Mendel Rabin [a,b,*], Carlos Eduardo Poli de Figueiredo [a], Mario Bernardes Wagner [a], Ivan Carlos Ferreira Antonello [a]

[a] *Programa de Pós-graduação em Medicina e Ciências da Saúde (Nefrologia), Laboratório de Nefrologia, IPB/HSL/FAMED, Brazil*
[b] *Cardiology Department Ergometry Unit, Pontifícia Universidade Católica do Rio Grande do Sul. Porto Alegre, Brazil*

ARTICLE INFO

Article history:
Received 29 September 2008
Received in revised form 12 February 2009
Accepted 14 February 2009

Keywords:
Taste threshold
Blood pressure
Exercise test
Salt

ABSTRACT

Salt taste sensitivity is the capacity to identify the flavour of salt. It is possible that salt taste sensitivity threshold (STST) can influence salt appetite, and sodium ingestion is associated with hypertension. The present study evaluates the relationship between salt taste sensitivity threshold (STST) and blood pressure (BP) response to exercise during a treadmill stress test. Two hundred and three normotensive individuals undergoing evaluation before starting an exercise training program were tested for STST, using concentrated saline solutions from 0.22 to 58.4 g/L. Patients were divided into two groups according to the STST: *normal* (*n-STST*) and *increased* (*i-STST*); and into two groups according to their BP response to exercise: *exercise-induced hypertension* (*EIH*) or *physiological blood pressure response* (*n-EIH*). EIH was detected in 49 (24.1%) individuals. Initial systolic and diastolic BP and their areas under the curves during the test were higher in the EIH group. Initial systolic and diastolic BP areas under the curves were significantly higher in i-STST than n-STST. There was an association between STST of at least 1.8 g/L (increased STST) and EIH (OR = 6.71, 95% CI 1.5–29.99) independent of gender, body mass index and age. Occurrence of EIH was associated to i-STST, suggesting that a relationship between high STST and increased BP response to exercise is possible.

Introduction

Salt taste sensitivity is the capacity to identify the flavour of salt. It is possible that salt taste sensitivity threshold (STST) can influence salt appetite, and sodium ingestion is associated with hypertension. The present study shows that patients with exercise-induced hypertension have a higher mean STST than patients with a physiological blood pressure response to exercise, and that a STST is independently associated with a higher risk of exercise-induced hypertension.

Arterial hypertension is associated with reduced life expectancy due to vascular, kidney, heart and cerebral injuries (Chobanian et al., 2003; JNC VI, 1997). Prevalence of arterial hypertension in Porto Alegre is estimated to vary between 13% and 30% depending on the blood pressure cut-off (Fuchs, 1994), and in other Brazilian cities it is estimated to be in the order of 22–44% (Sociedade Brasileira de Hipertensão, Sociedade Brasileira de Cardiologia, Sociedade Brasileira de Nefrologia, 2004).

The Intersalt study investigated, in a systematic and standardized way the relationship between electrolytes excretion and blood pressure, based on samples collected in several countries (Intersalt, 1988). The study showed that, within centres sodium excretion was significantly related to blood pressure in individual subjects. Sodium excretion was also significantly related across centres to the slope of blood pressure with age, and it was suggested that a lower average sodium intake might have a favourable influence on blood pressure, on change of blood pressure with age, and hence on cardiovascular mortality (Intersalt, 1988).

Food intake is our main salt source, and the taste of salt can be sensed in the tongue. The taste recognition threshold may be defined as the concentration at which a subject identifies a taste solution (Nilsson, 1979), and salt taste sensitivity is the capacity to identify salt. Sodium appetite is a strong motivation to seek, obtain, and ingest sodium (Stricker, 1980), so it is possible that STST can influence salt appetite, and taste may be a primary food selection determinant.

Under normal conditions, during a treadmill test, systolic pressure increases according to the intensity of the exercise, (usually no higher than 220 mmHg) and diastolic blood pressure remains relatively constant or oscillates 10 mmHg at the most (Grim, Weinberger, Higgins, & Kramer, 1977). In 1997, Nazar et al. in a group of normotensive individuals with exaggerated blood pressure response to exercise showed greater cardiac output with normal heart rate and total peripheral resistance. Besides,

* Corresponding author at: Centro Clínico PUCRS Conj 205, Avenida Ipiranga 6690, Porto Alegre, RS, CEP 90610.000, Brazil.
E-mail address: mrabin@uol.com.br (M. Rabin).

0195-6663/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.appet.2009.02.007

erythrocyte sodium content was higher in such patients in comparison to controls. In a cohort study, Jackson, Squires, Grimes, and Beard (1985) described that patients with exercise-induced hypertension develop arterial hypertension 4 years later, suggesting that exercise-induced hypertension may be implicated as a risk factor to future arterial hypertension. Spritzer (1985) suggested that hypertensive individuals may have higher thresholds to salt when compared to normotensive subjects.

The relationship between salt taste sensitivity threshold and blood pressure has been recently evaluated in children. A significant correlation between blood pressure and salt taste perception was detected in healthy adolescent (Málaga et al., 2003). Children with at least one of the parents with essential hypertension had a lower STST. Besides, STST was correlated with SBP in the non-obese children, and it has been suggested that there is evidence for a linkage between high blood pressure, salt intake and sensitivity, perinatal environment and obesity (Arguelles et al., 2007; Málaga et al., 2003).

The association between EIH and STST has not been previously examined. The blood pressure response to exercise is related to cardiovascular events, such as stroke and myocardial infarction, and has been suggested as an additional tool to identify subjects under risk who could benefit from preventive measures (Kurl et al., 2001; Laukkanen et al., 2006; Mundal et al., 1996). Abnormal systolic blood pressure increase after exercise is also a predictor of cardiovascular mortality (Huang et al., 2008).

The present study evaluates the relationship between the salt taste sensitivity threshold and the blood pressure response to exercise during a treadmill stress test. We are not aware of any previous study examining such relationship.

Patients and methods

This is a cross-sectional study evaluating salt taste sensitivity threshold and blood pressure during treadmill stress test.

Normotensive individuals were defined as those without prior history of arterial hypertension and not using antihypertensive drugs. The treadmill exercise test was carried out according to *Bruce's* protocol (Bruce, 1956). Normotensive patients aging from 18 to 60 years, without ischemic heart disease were included. Patients with diabetes, neuropathy, using total superior or inferior dental prostheses, or taking any drugs or medications were not included. Patients were normal individuals undergoing evaluation before starting an exercise training program, at the request of their own clinicians or referred by a Fitness Center.

They were not allowed to smoke, eat food or brush their teeth for at least 1 h before the salt taste sensitivity threshold test. Exclusion criteria, after the beginning of the stress test, include those individuals unable to endure 6 min of exercise, or whose test suggested ischemic coronary heart disease. For analysis purposes, patients were divided into two groups according to the STST: *normal STST* (*n-STST*) and *increased STST* (*i-STST*); and into two groups according to their blood pressure response to exercise on the treadmill test: *exercise-induced hypertension* (*EIH*) or *physiological blood pressure response* (*n-EIH*).

The procedure used by Nilsson (1979) was the one chosen for determining the salt taste recognition threshold. Sodium chloride (NaCl) solutions were applied on the tip of the tongue using a dropper. Five drops of the test solution were placed on the tongue. After 10 s without breathing or closing the mouth, the volunteer mentioned which taste was perceived. The solutions were offered in increasing concentrations until a correct identification of the taste. If the same concentration was identified twice, less concentrated solutions were used until an identification error occurred. The lowest concentration of the test solution that could be distinguished was considered as the threshold for NaCl recognition. To avoid adaptation of the gustative sensors, tests were carried out with progressive concentrations, but in "jumps", until occurrence of an error or a hit. Between tests, the mouth was washed with distilled water, with 30 s intervals among successive tests. Table 1 shows the concentrations of each test solution.

Table 1
Concentration of sodium chloride in all bottles.

Bottle number	NaCl Concentration	
	g/L	mol/L
1	0.22	0.004
2	0.45	0.008
3	0.9	0.015
4	1.8	0.030
5	3.6	0.060
6	7.3	0.120
7	14.6	0.150
8	29.2	0.500
9	58.4	1

According to Nilsson (1979) and Spritzer (1985), the STST value for salt recognizing in normotensive individuals is 0.015 mol/L of NaCl (0.9 g/L), equivalent to solution number 3 used in this work.

After the salt testing, participants performed the treadmill test, with gradually increasing loads, in accordance with the Bruce protocol (Bruce, 1956). Speed and inclination are increased every 3 min. Blood pressure and ECG tracing are obtained simultaneously. When exercise is ceased blood pressure is measured every minute, until it reaches normal or pre-exercise values. An Imbramed ATL-10200 treadmill (Porto Alegre, Brazil) was used.

The blood pressure responses to exercise in this study were considered *physiological* or *exaggerated*. Blood pressure is normal at the start of the test. In the physiological response, during exercise there is a progressive increase of the systolic component, up to a maximum of 219 mmHg. The diastolic component remains unchanged or shows a small decrease of 10 mmHg or more. On the other hand, exercise hypertension is an exaggerated blood pressure response to exercise leading to a steep increment of the systolic blood pressure, reaching at least 220 mmHg and the diastolic component also shows an increase of more than 10 mmHg. In both cases, the blood pressure tends to return to its baseline value (Andrade et al., 2002).

The study protocol was approved by the University Scientific and Ethics Committee and all patients signed the "informed consent".

Quantitative data were summarized using mean and standard deviation, whereas for categorical variables we have used frequencies and percentages. For NaCl solutions concentrations the median and interquartile range (P25−P75) was used. Groups were compared using Student's t test (continuous data) or chi-square test. Associations were evaluated using odds ratio with 95% confidence intervals and a logistic regression model to control for the effect of potential confounding factors. Significance level was set to 5%. Data were analyzed with the help of the Statistical Package for the Social Sciences (SPSS) version 11.

Results

The study included 246 individuals. Forty-three individuals were censured according to the exclusion criteria, resulting in a final sample of 203 to be analyzed. Mean age was 41.4 ± 9.8 years, 58.6% were male, 90.6% were Caucasians, with an average body mass index of 25.9 ± 4.0, 15% were smokers and 67% had a family history of arterial hypertension. Patients BMI categories were as follows: normal weight (BMI 18.5–24.9) $n = 97$ (47.8%), overweight (BMI 25–29.9) $n = 86$ (47.4%) and obesity (BMI of at least 30) $n = 20$ (9.9%).

Table 2
Comparison between the groups EIH and n-EIH.

Variable	EIH (n = 49)	n-EIH (n = 154)	OR*	95% CI	P
Male, n (%)	43 (87.8)	76 (49.4)	7.4	3.0–18.2	<0.001
Age, years	41.2 ± 9.7	41.6 ± 9.8	−0.4	−3.6–2.8	0.803
White N (%)	43 (87.8)	141 (91.6)	0.7	0.2–1.8	0.410
BMI (kg/m^2)	27.9 ± 4.6	25.2 ± 3.5	2.7	0.6–1.5	<0.001
AH family History no. (%)	34 (69.4)	102 (66.2)	1.2	0.6–2.3	0.815
Alcohol n (%)	39 (79.6)	106 (68.8)	1.8	0.8–3.8	0.204
Smoke N (%)	10 (20.4)	22 (14.3)	1.5	0.7–3.5	0.424
STST ≥ score	5.0 ± 1.1	4.1 ± 1.3	0.9	0.4–1.3	<0.001
STST ≥ 4	47 (95.9)	110 (71.4)	9.4	2.2–40.4	0.001
NaCl (mol/L)	0.06 (0.06–0.12)	0.03 (0.02–0.06)	0.03	–	<0.001

Data are presented as mean ± standard deviation, median (interquartile range) or number (percent). BMI: body mass index; AH: arterial hypertension; STST: salt taste sensitivity threshold. OR: odds ratio for categorical variables or difference in the means for continuous variables.

Mean STST score was 4.3 ± 1.4, and the median (IQI) was 1.8 g/dL (1.8–3.5) [or 0.03 M (0.03–0.06)] corresponding to a score of 4 (4–5). Exaggerated response to exercise (*EIH*) was detected in 49 (24.1%) individuals. Table 2 shows the comparison between the groups EIH and n-EIH. There was a higher proportion of men in the EIH group and the body mass index was also higher. STST scores and the percentage of individuals with scores of at least 4 were significantly higher in the EIH group.

Systolic and diastolic blood pressure were higher in the EIH group during the whole treadmill test and recovery period. Systolic (4350 ± 271 and 3534 ± 331, $P < 0.001$) and diastolic (2205 ± 192 and 1913 ± 160, $P < 0.001$) blood pressure area under the curve was significantly higher in EIH than n-EIH. Mean initial systolic blood pressure was 137 ± 15 and 118 ± 13 mmHg in EIH and n-EIH, respectively ($P < 0.001$), and initial diastolic blood pressure was 88 ± 7 and 76 ± 9 mmHg in EIH and n-EIH, respectively ($P < 0.001$).

Mean initial systolic blood pressure were 124 ± 16 and 117 ± 11 mmHg in i-STST and n-STST respectively ($P < 0.001$), and initial diastolic blood pressure was 80 ± 10 and 76 ± 8 mmHg in i-STST and n-STST respectively ($P = 0.003$). Blood pressures during the whole test in individuals with n-STST and i-STST are illustrated in Fig. 1. Systolic (3817 ± 468 and 3435 ± 353, $P < 0.001$) and diastolic (2016 ± 210 and 1874 ± 166, $P < 0.001$) blood pressure area under the curve was significantly higher in i-STST than n-STST.

Our results could be confounded by differences in baseline blood pressure between the subjects with increased and normal salt-taste sensitivity, so adjustments were performed. Mean systolic and diastolic blood pressure area under the curve were still significantly higher ($P < 0.001$ and $P < 0.001$) in i-STST than n-STST when adjusted by basal blood pressure. Further, the difference of initial blood pressure and the highest blood pressure measurement during exercise for each individual (Δ peak) was calculated. Mean systolic Δ peak was 64.3 ± 26 mmHg for i-STST and 45.1 ± 26.9 mmHg for n-STST ($P < 0.001$, t-test) with a mean difference of 19.1 (95% CI 10.4–27.9). After adjusting for initial systolic blood pressure, the effect remained significant ($P < 0.001$), with a mean adjusted difference of 16.5 (95% CI 7.7–25.3). Mean diastolic Δ peak was 12.1 ± 9.6 mmHg for i-STST and 9.6 ± 8.0 mmHg for n-STST ($P < 0.11$, t-test) with a mean difference of 2.5 (95% CI −0.6–5.6). After adjusting for initial diastolic blood pressure the effect was significant ($P = 0.039$) with a mean adjusted difference of 3.3 (95% CI −0.2–6.4).

Logistic regression analysis is shown in Table 3**,** analyzing EIH as the dependent variable. There was an association between STST ≥4 (increased STST) and EIH (OR = 6.71, 95% CI 1.50–29.99, $P = 0.013$) independent of gender, body mass index and age. Besides, male gender (OR 7.72, 95% CI 2.82–21.10, $P < 0.001$) and body mass index (OR 1.18, 95% CI 1.066–1.305, $P = 0.001$) were more prone to have EIH.

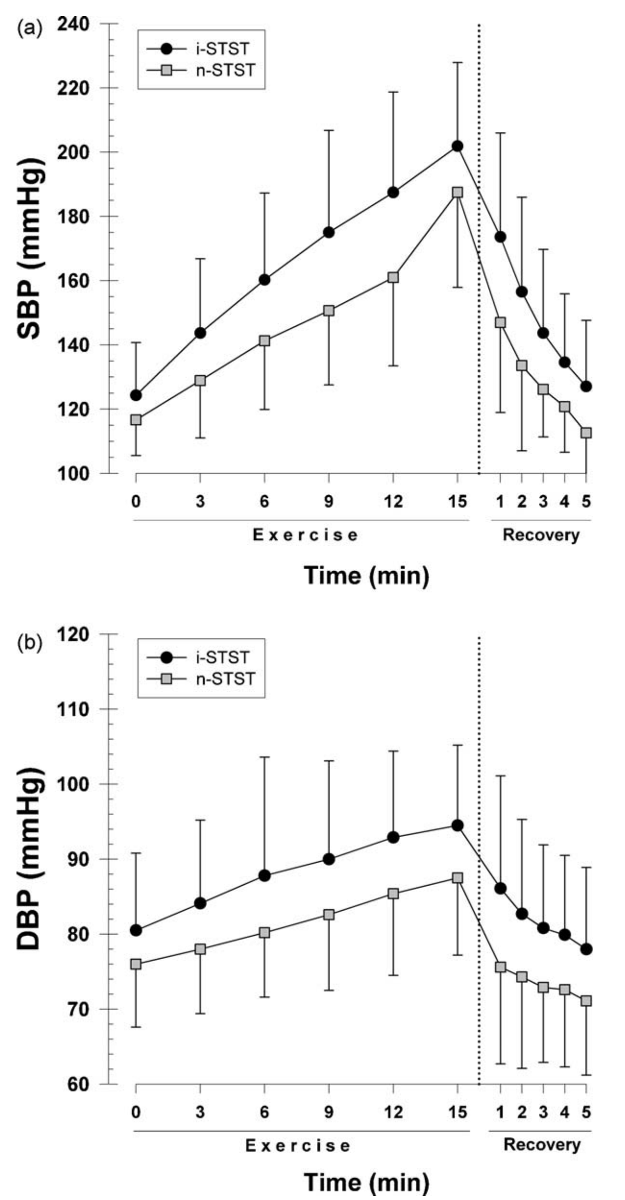

Fig. 1. Blood pressure during the whole treadmill test and recovery period in patients with normal salt taste sensitivity threshold (n-STST) and increased salt taste sensitivity threshold (i-STST). (a) Represents systolic blood pressure (SBP) and (b) diastolic blood pressure (DBP). Error bars correspond to standard deviation.

Table 3
Logistic regression model for occurrence of exercise-induced hypertension (EIH) ($n = 203$).

Variable	*n*	OR	IC 95%	*P*
STST				
High (STST $\geq$ 4)	157	6.71	1.50–29.99	0.013
Normal (STST < 4)[a]	46	1.0	–	
Gender				
Male	119	7.72	2.82–21.10	<0.001
Female[a]	84	1.0	–	
Age, years	203	1.001	0.963–1.042	0.942
Body mass index (kg/m^2)	203	1.180	1.066–1.305	0.001

STST = score of salt taste sensitivity threshold; OR = odds ratio; 95% CI = 95% confidence interval.
[a] Reference category.

A STST above 1.8 g/L or more had a high sensitivity of 95.9% (95% CI 84.9–99.3), but a low specificity 28.6% (95% CI 21.7–36.5) to detect EIH.

Discussion

The present study shows that patients with exercise-induced hypertension have a higher mean STST than patients with a physiological blood pressure response to exercise, and that a STST of at least 1.8 g/L was independently associated with a higher risk of exercise-induced hypertension. A STST of at least 1.8 g/L had a high sensitivity, but a low specificity, to detect exercise-induced hypertension.

This study demonstrated that among the 203 individuals tested, 49 (24.1%) presented exercise-induced hypertension and 154 (75.9%) had a physiological blood pressure response to exercise. This slightly higher prevalence of exercise-induced hypertension, in comparison to 18% described in the CARDIA (Manolio et al., 1994) study, might be due to the fact that this study was performed in the Ergometry Service of a University hospital.

Mean initial systolic and diastolic blood pressure were normal at the beginning of the treadmill test, but in the exercise-induced hypertension (*EIH*) group mean blood pressure would be classified as pre-hypertension in accordance to the VII JNC (Chobanian et al., 2003). During the course of the test, mean blood pressure in the exercise-induced hypertension group increased above physiological values, while in the n-EIH group it remains within normality. Furthermore, it was observed that in the recovery period the n-EIH group returns to the initial blood pressure values or even lower, while in the exercise-induced hypertension group recovery is slower and blood pressure values remains higher than the initial ones.

Spritzer (1985) had previously showed that the STST was higher in non-treated hypertensive patients than in normotensive control group. The present study also shows that the gustatory threshold to salt was higher in a special group of individuals (EIH). The resting blood pressure of the group with STST equal or above 0.030 mol/L (1.8 g/L) was higher (124/81 mmHg) than in patients with lower threshold (117/76 mmHg).

When analyzing the blood pressure curve in response to exercise in the group with increased STST, as compared to the group with normal STST, one finds that there is a more pronounced elevation in the blood pressure curve of those with higher STST in relation to normal sensitivity, both for systolic blood pressure and for diastolic blood pressure. Besides, similarly to the exercise-induced hypertension (EIH) group analyzed before, blood pressure at the end of the test remains somewhat higher than at the start for systolic blood pressure, while diastolic blood pressure gets back to slightly lower levels than the initial ones.

Sensitivity to salt is a matter already thoroughly studied (Campese, 1994; Weinberger, Miller, Luft, Grim, & Finenberg, 1986). One knows that the hypertensive response to salt overload is more prevalent in some ethnic groups, independent of the severity of hypertension (Campese, 1994; Weinberger et al., 1986). Campese et al. (1982) and Campese (1994) found that 60% of patients with essential hypertension to be salt-sensitive, while normotensive patients were salt-resistant. Weinberger et al. (1986), Grim et al. (1977) and Weinberger (1996) evaluated the salt sensitivity in normotensive and hypertensive individuals. The responses were heterogeneous and formed a Gaussian distribution in both groups (Weinberger, 1996; Weinberger et al., 1986). The hypertensive individuals were significantly more salt sensitive than the normotensive individuals. They found that 26% of the normotensive subjects were salt sensitive and 58.4% were salt resistant; in the hypertensive group, 51% were sensitive and 33.3% were resistant, while 15.7% in both groups had indeterminate response to sodium (Weinberger, 1996).

The biological basis of sodium appetite is still obscure (Stricker & Verbalis, 1991). STST is a personal characteristic of the individual and may eventually be a practical way to evaluate who eats more salt (Spritzer, 1985). Salt sensitivity is usually defined based on the blood pressure response to a sodium load. In the present sample only 2 patients with exercise-induced hypertension had a normal STST. This suggests that this group of patients may be eating more salt than the n-EIH subjects. Some individuals with a higher STST do not have increased blood pressure, and this may be characterizing those with increased resistance to salt, despite a higher salt ingestion. It is also possible that we may be dealing with a reliable marker of salt ingestion, but urinary sodium excretion and salt ingestion were not measured, so we cannot confirm this hypothesis. Our group has previously shown that normotensive individuals with a higher STST, had a higher sodium urinary excretion, a putative marker of sodium intake (Antonello, Antonello, & de los Santos, 2007). The higher STST seems to be a marker to higher appetite and ingestion of the salt and consequently increased sodium urinary excretion. Exercise-induced hypertension is a phenomenon with mechanisms that are still not clear, and the present study shows that they have a higher STST. Some individuals are more sensitive regarding salt recognition, so they may ingest more or less salt according to their perception.

Exercise-induced hypertension was also independently associated with gender (male had a higher risk), and body mass index. Correlation with age did not show any significant association, but it must be mentioned that individuals above 60 years were not included.

The study suggests that evaluating STST may be a way to evaluate an inherited characteristic, a simple way to verify in the clinic the gustatory sensitivity threshold to salt. The role of gustatory sensitivity to salt has to be further studied to answer the questions raised from the present study. Investigating STST and its associations with urinary salt excretion, hypertension genetic markers and vascular disease risk factors, may help to determine the relevance of this simple test.

Conflict of interest statement

The authors declare that they have no conflict of interest regarding the present study.

Acknowledgements

The Nephrology Laboratory (IPB) is supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenadoria de Aperfeiçoamento de Pessoal de Ensino Superior (CAPES), Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul (FAPERGS), Secretaria de Ciência e Tecnologia do Estado do Rio Grande do Sul (SCT) and Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS) and by the Nephrology Division HSL. Poli de Figueiredo is a CNPq Researcher.

Contributors: MR and ICA participated in all steps of the study, CEPF contributed in the discussion, critical analysis and writing the paper, MBW was the biostatistician and epidemiologist who contributed the study analysis.

Sources of support: The Nephorology Laboratory (IPB) is supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenadoria de Aperfeiçoamento de Pessoal de Ensino Superior (CAPES), Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul (FAPERGS), Secretaria de Ciência e Tecnologia do Estado do Rio Grande do Sul (SCT) and Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS) and by the Nephrology Division HSL.

References

Andrade, J., Brito, F. S., Vilas-Boas, F., Castro, I., Oliveira, J. A., Guimarães, J. I., et al. (2002). II Diretrizes da Sociedade Brasileira de Cardiologia Sobre Teste Ergomé-trico. *Arquivos Brasileiros de Cardiologia 78(suppl) pp. 21–17.*

Antonello, V. S., Antonello, I. C. F., & de los Santos, C. A. (2007). Limiar de sensibilidade gustativa ao sal, natriúria de 24 horas e pressão arterial em indivíduos normotensos. *Revista da Associação Médica Brasileira, 53*, 142–146.

Arguelles, J., Díaz, J. J., Málaga, I., Perillán, C., Costales, M., & Vijande, M. (2007). Sodium taste threshold in children and its relationship to blood pressure. *Brazilian Journal of Medical and Biological Research, 18*, 431–434.

Bruce, R. A. (1956). Evolution of functional capacity and exercise tolerance of cardiac patients. *Modern Concepts of Cardiovascular Diseases, 25*, 321–326.

Campese, V. M., Romoff, M. S., Levitan, D., Saglikes, Y., Friedler, R. M., & Massry, S. G. (1982). Abnormal relationship between sodium intake and sympathetic nervous system activity in salt-sensitive patients with essential hypertension. *Kidney International, 21*, 371–378.

Campese, V. M. (1994). Salt sensitivity in hypertension, renal and cardiovascular implications. *Hypertension, 23*, 531–550.

Chobanian, A. V., Bakris, G. L., Black, H. R., Cushman, W. C., Green, L. A., Izzo, J. L, Jr. et al. (2003). National heart, lung, and blood institute joint national committee on prevention, detection, evaluation, and treatment of high blood pressure; national high blood pressure education program coordinating committee. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. The JNC 7 report. *Journal of The American Medical Association, 289*, 2560–2572.

Fuchs, F. D. (1994). Hipertensão arterial sistêmica: epidemiologia e prevenção. *Arquivos Brasileiros de Cardiologia, 63*, 443–444.

Grim, C. E., Weinberger, M. H., Higgins, J. T., & Kramer, N. J. (1977). Diagnosis of secondary forms of hypertension: a comprehensive protocol. *Journal of the American Medical Association, 237*, 1331–1335.

Huang, C.-L., Su, T.-C., Chen, W.-J., Lin, L.-Y., Wang, W.-L., Feng, M.-H., et al. (2008). Usefulness of paradoxical systolic blood pressure increase after exercise as a predictor of cardiovascular mortality. *American Journal of Cardiology, 102*, 518–523.

Intersalt Cooperative Research Group. (1988). Intersalt: an international study of electrolyte excretion and blood pressure. Results for 24 hour urinary sodium and potassium excretion. *British Medical Journal, 297*, 319–328.

Jackson, A. S., Squires, W. G., Grimes, G., & Beard, E. F. (1985). Prediction of future resting hypertension from exercise blood pressure. *Journal of Cardiac Rehabilitation, 3*, 263–268.

Kurl, S., Laukkanen, J. A., Rauramaa, R., Lakka, T. A., Sivenius, J., & Salonen, J. T. (2001). Systolic blood pressure response to exercise stress test and risk of stroke. *Stroke, 32*, 2036–2041.

Laukkanen, J. A., Kurl, S., Rauramaa, R., Lakka, T. A., Venäläinen, J. M., & Salonen, J. T. (2006). Systolic blood pressure response to exercise testing is related to the risk of acute myocardial infarction in middle-aged men. *European Journal of Cardiovascular Prevention and Rehabilitation, 13*, 421–428.

Málaga, S., Díaz, J. J., Arguelles, J., Perillán, C., Málaga, I., & Vijande, M. (2003). Blood pressure relates to sodium taste sensitivity and discrimination in adolescents. *Paediatric Nephrology, 18*, 431–434.

Manolio, T. A., Burke, G. L., Savage, P. J., Sidney, S., Gardin, J. M., & Oberman, A. (1994). Exercise blood pressure response and 5-year risk of elevated blood pressure in a cohort of young adults: the CARDIA study. *American Journal of Hypertension, 7*, 234–241.

Mundal, R., Kjeldsen, S. E., Sandvik, L., Erikssen, G., Thaulow, E., & Erikssen, J. (1996). Exercise blood pressure predicts mortality from myocardial infarction. *Hypertension, 27*, 324–329.

Nazar, K., Kaciuba-Uscilko, H., Ziemba, W., Krysztofiak, H., Wojcik-Ziolkowska, E., Niewiadomski, W., et al. (1997). Physiological characteristics and hormonal profile of young normotensive men with exaggerated blood pressure response to exercise. *Clinical Physiology, 17*, 1–18.

Nilsson, B. (1979). Taste acuity of the human palate. III. Studies with taste solutions on subjects in different age groups. *Acta Odontologica Scandinavica, 37*, 235–252.

Sociedade Brasileira de Hipertensão, Sociedade Brasileira de Cardiologia, Sociedade Brasileira de Nefrologia. (2004). IV Diretrizes brasileiras de Hipertensão Arterial. *Arquivos Brasileiros de Cardiologia, 82*(suppl. IV), 7–14.

Spritzer, N. (1985). Limiares gustativos ao sal em pacientes com hipertensão arterial. *Arquivos Brasileiros de Cardiologia, 44*, 151–155.

Stricker, E. M. (1980). The physiological basis of sodium appetite: a new look at the "depleted–repletion" model. In M. R. Kare, M. J. Fregly, & R. A. Bernard (Eds.), *Biological and behavioral aspects of salt intake* (pp. 85–202). New York: Academic Press.

Stricker, E. M., & Verbalis, J. G. (1991). Biological bases of sodium appetite: excitatory and inhibitory factors. In M. I. Friedman, M. G. Tordoff, & M. R. Kare (Eds.), *Chemical senses* (pp. 3–17). New York: Marcel Dekker.

The sixth report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure (JNC VI) (1997): *Archives of Internal Medicine*, 157, 2413–2446.

Weinberger, M. H. (1996). Salt sensitivity of blood pressure in humans. *Hypertension, 27*, 481–490.

Weinberger, M. H., Miller, J. Z., Luft, F. C., Grim, C. E., & Finenberg, N. S. (1986). Definitions and characteristics of sodium sensitivity and blood pressure resistance. *Hypertension, 8*(Pt 2), II127–II134.