Original Article

Prevalence, awareness, treatment and control of hypertension and salt intake in Portugal: changes over a decade. The PHYSA study

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Objective: To determine prevalence, awareness, treatment and control of hypertension and the 24-h sodium excretion (24h-UNa) in the Portuguese adult population and to examine their changes from a similar study done in 2003.

Design and setting: A population-based cross-sectional survey conducted in 2011–2012.

Methods: A multistage-stratified (by age and sex) sampling method was used to select a representative sample of the 18–90-year-old population yielding 3720 participants (52.6% women, 97.1% Caucasians). Hypertension was defined as a SBP of at least 140 mmHg or DBP of at least 90 mmHg [average of 2–3 blood pressure (BP) measurements by trained observers with OMRON M6] or reported knowledge or treatment with antihypertensive drugs at the first visit (V1). A complete clinical information was obtained with a standard questionnaire. This procedure was repeated 10–15 days after visit 2 (V2) and 24-h urinary sample was collected for 24h-UNa, 24-h potassium excretion and creatinine excretion.

Results: The overall prevalence of hypertension at V1 was 42.2% (44.4% in men, 40.2% in women) (42.1% in 2003). The age-specific prevalence of hypertension was 6.8, 46.9 and 74.9% in people below 35 years, 35–64 years and above 64 years. Comorbidities were 2.2–6.3 times more common in hypertensive patients vs. normotensive individuals. Overall, among the hypertensive patients, 76.6% were aware of the hypertension condition, 74.9% were treated and 42.5% were controlled (BP $<$140/90 mmHg), that is, respectively, 1.7, 1.9 and 3.8 times higher vs. data in 2003, with lower values in men vs. women and younger vs. older people. Global mean BP was 127.4/74.6 $\pm$ 17.7/10.5 vs. 134.7/80.4 $\pm$ 21.2/14.1 mmHg in 2003. From V1 to V2, control of hypertension increased on average by 14.8%. Multivariate analysis showed that age and BMI were independently associated with prevalence of hypertension. 24h-UNa (84% valid urinary samples) was 182.5 $\pm$ 64.7 mmol/day (10.7 g salt/day) and 24-h potassium excretion 75.2 $\pm$ 26.1 mmol/day. 24h-UNa was higher in patients with hypertension than in normotensive individuals (185.4 $\pm$ 64.8 vs. 177.8 $\pm$ 64.5 mmol/day; $P < 0.02$) and correlated with SBP ($r = 0.05$), age ($r = 0.08$) and BMI ($r = 0.10$) ($P < 0.01$).

Conclusion: Hypertension prevalence among Portuguese adults remained stable in the past decade, but proportions of awareness, treatment and control of hypertension improved significantly. Salt intake is still high being almost double the WHO recommendations.

Keywords: awareness, control, hypertension prevalence, salt intake, treatment

Abbreviations: 24h-UK, 24-h potassium excretion; 24h-UNa, 24-h sodium excretion; BP, blood pressure

INTRODUCTION

Cardiovascular disorders are the principal cause of mortality worldwide [1] and arterial hypertension is recognized as a major risk factor for the development of cardiovascular disease [2]. It is well established that treatment of hypertension can reduce the risk of cardiovascular events, including stroke, coronary disease, cardiac and renal failure [3]. National surveys of prevalence, awareness, treatment and control are essential pieces of knowledge for assessing the burden of hypertension in countries, regions and communities. Estimations of hypertension prevalence show a wide variation between countries [4] and some relevant changes in population mean blood pressure (BP) have been reported over decades within each country [5]. Studies have demonstrated significant improvements in the prescribing rates of antihypertensive medications over one decade with attendant decreases in hypertension-related cardiovascular events [6]. In Portugal, a nation-wide survey of hypertension was conducted in 2003 [7] showing an age-adjusted prevalence of hypertension of 42.1% and a level of hypertension control of 11.2%.

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Now, a decade after, we performed a new cross-sectional national representative survey of awareness, treatment and control of hypertension, thereby comparing data of both surveys. Meanwhile, high salt intake has been associated with increase in BP [8] and more recently also with a higher risk of stroke and total cardiovascular events [9]. Reduction of dietary salt intake has been claimed to lower BP in both hypertensive and normotensive individuals [10]. Medical scientific guidelines [11,12] have recommended a general reduction of dietary salt intake to less than 6 g/day based on its favorable effects on BP levels and on the hypothetical benefits in terms of reduction in cardiovascular morbidity and mortality [13]. Some small pilot studies [14,15] have suggested that in Portugal, high levels of salt intake are common, but no national study was previously developed to assess the overall salt intake of the Portuguese population. Thus, in the present survey, we also evaluated the salt intake of the Portuguese population by measuring the 24-h sodium excretion (24h-UNa).

MATERIAL AND METHODS

This was a population-based cross-sectional survey fully designed, directed and supported by the Portuguese Society of Hypertension, and was conducted between November 2011 and December 2012. The study protocol was approved by Administração Regional de Saude (ARS), that is, Regional Health Administration, North; ARS South Ethical Committees; and Comissão Nacional de Protecção de Dados (CNPD), that is, National Committee for Data Protection, and all participants gave their informed consent. A multistage-stratified (by age and sex) cluster random sampling method was used to select a nationally (Portugal continental) representative sample of the general population aged 18–90 years old based in 2001 recent National census data. Stratification was based on age (three groups, i.e. <35, 35–64 and >64 years), sex (two groups, i.e. female and male), and health regions of the country (five health regions). Community local clinical health service centers were the basis for recruitment. A list of primary healthcare centers of the continental National Health Service or equivalents was prepared in each region in order to be randomly chosen and allocated to a regional sample proportionate to the population of each region and to the size of their catchment population in sampled care centers. Strata were selected by a proportional sampling methodology according to the lists of patients inscribed in primary healthcare centers that include more than 84% of the Portuguese population. Each stratum had a proportional size according to the population of each region, and to the selected care centers considered as representative of each region. Participants were randomly selected from the care centers lists and convened by letter and/or phone. Age and sex sampling for each stratum were performed by quota-sampling method for determining the sample size according to the estimated prevalence of hypertension in each age/sex group. The estimated sample size with a precision error of 1.39% was 3720 persons based on the 2001 Portuguese census.

All interviews and examinations were conducted in a quiet room of each primary healthcare center after standardized protocol. In the first visit (visit 1), a standard questionnaire was administered by trained investigators to obtain information on demographic characteristics, personal and family history of chronic diseases, lifestyle risk factors, and conditions about diagnosis, and current treatment of hypertension, diabetes, dyslipidemia, and of other cardiovascular and noncardiovascular disorders. In particular, the questions on the awareness of hypertension were conducted before starting the measurements of BP. In all participants, height and weight were measured for estimation of body surface (weight divided by the height squared) and waist and hip circumferences were measured by standard methods. Presence of dyslipidemia and diabetes was considered by participant's awareness of these conditions or current use, respectively, of antidyslipidemic or antidiabetic drugs. Presence of previous cardiovascular events (stroke, transient ischemic attack, myocardial infarction, angor pectoris, and cardiac failure) was considered by the clinical history referred by patients or relatives or medically documented. Family history of hypertension was considered if this condition was recognized at least in one parent. Educational attainment was determined by years of schooling and level of graduates. For the purpose of this analysis, each participant was classified into one of the three categories: low level of education, that is, less than 6 years; medium level of education, that is, at least 6 but not more than 9 years; high level of education, that is, more than 9 years of education.

Blood pressure measurement

Blood pressure was measured by trained staff with OMROM M6 automatic sphygmomanometers (Omron Healthcare, The Netherlands) using appropriate cuffs according to individual-sized arms. Initially, each participant's BP was measured simultaneously in both arms after 15 min of resting comfortably in sitting position and wearing light clothes. The arm with the highest reading was that used for future measurements. After another 5 min of resting, two additional recordings of BP were taken 5 min apart in that arm. We considered as the BP for the purpose of the present study (BP – visit 1) the average of the three readings or the average of only these two last readings if there was a difference at least 10 mmHg of SBP from the first reading to the second one. Three minutes after the last of these readings, another BP recording was taken after 3 min of standing up from the sitting position. Participants had to have refrained from smoking and drinking caffeinated drinks or alcohol and undertaken any strenuous physical exercise in the 30 min before the measurements. In that visit 1, occasional urinary collection was also done in 10-ml vials for future measurement of urinary excretion of sodium, potassium, creatinine and albumin – stored during the day at −80°C, and saliva for future genetic analysis (data on that will be not shown in that publication). All participants were invited to return 10–15 days (visit 2) after the first visit in order to be examined in the same place and hour as in visit 1 while not changing their habits and medications from the previous visit. At visit 2, protocol of measuring BP was similar to that of visit 1, with the three measurements done in the arm with the highest value identified at visit 1.

By using data collected at visit 1, hypertension was defined as a SBP of at least 140 mmHg or DBP of at least 90 mmHg, if the participant reported a history of hypertension, or if the participant reported taking antihypertensive medication in any moment of their life. Awareness of hypertension was defined as participant's self-report of any previous diagnosis of hypertension by a healthcare professional (except if only during pregnancy). The treatment of hypertension was defined as self-reported use of a prescription medication for the treatment of hypertension in the past 2 weeks. Control of hypertension was defined as a patient who was receiving pharmacological treatment for hypertension and in which case SBP was below 140 mmHg and DBP was below 90 mmHg. By definition, patients called 'treated hypertensives' were aware of their hypertensive diagnosis and those called 'controlled hypertensives' were under drug treatment. Postural hypotension was considered as a drop of SBP of at least 20 mmHg from the last of the two sitting BP measurements to the 3-min standing BP measurement. Isolated systolic hypertension (ISH) was defined as a SBP at least 140 mmHg and a DBP below 90 mmHg. Resistant hypertension was defined as a patient who had a BP of at least 140 mmHg or DBP of at least 90 mmHg under three or more antihypertensive medications (including a diuretic), or as SBP below 140 mmHg and DBP below 90 mmHg under four or more antihypertensive medications. BMI was calculated from the equation (body weight in kg divided by height in m^2). Smoking was classified as current, ex-smoker (not for at least 1 year) and nonsmoker. All patients on regular medications were asked to bring all their medications with them to the survey site during the second visit and to bring a 24-h urinary sample, the collection of which should be completed in the morning of the day of visit 2. Visit 2 was also used to improve and complete the information on the data collected during visit 1 and to deliver the collected 24-h urinary samples.

Twenty-four hour urine collection

The 24h-UNa was used to determine actual levels of daily sodium intake. Patients were instructed to start the 24-h urinary collection after getting up in the morning of the day before the visit 2 and to maintain their usual dietary, therapy and physical activity patterns between visit 1 and visit 2. The first morning urine specimen on that day was discarded and thereafter all the urine specimens were collected in appropriated 3-l containers during the entire day, during the night and including the first morning urine when getting up on the following day. During the 24 h of urine collection, the urine samples were kept stored in a refrigerator at 4°C until the next day. Once the total urinary collection was returned, the total urine volume was measured and four 10-ml aliquots were collected and immediately stored at −20°C and in the same day transported to the central lab to be preserved at −80°C until analysis. All urinary analyses were performed in duplicated samples in the same central laboratory in Porto. Sodium and potassium in urine were measured by flame photometry and creatinine by an automated validated enzymatic method. Urinary albumin excretion was assessed by an immunoturbidimetry assay (Roche Diagnostics, Mannheim, Germany). Creatinine excretion was measured to assure completeness of 24-h urinary collections. Valid 24-h urinary collections were only considered if 24-h urinary creatinine/kg of weight were between 18.5 and 25.0 mg/kg (men 18–50 years), 15.7 and 20.2 mg/kg (men 51–75 years), 16.5 and 22.4 mg/kg (women 18–50 years), and 11.8 and 16.1 mg/kg (women 51–75 years) [16]. Otherwise, values outside these ranges dictated the exclusion of that sample from final analysis. The estimated salt intake was derived from 24h-UNa as 1 mmol/24 h sodium = 0.05844 g/day salt.

Statistical analysis

Data are shown as mean ± SD if normally distributed or otherwise as a percentage. Continuous variables in patient groups were compared by analysis of variance with Bonferroni correction. Categorical variables were compared by chi-square test. Urinary sodium excretion as a marker of sodium intake and urinary potassium excretion as a marker of potassium intake were analyzed as a continuous variable. Linear regression analysis with Pearson's test was performed between urinary sodium and potassium excretion and hemodynamic and demographic variables. The significance of the relation of various risk factors with prevalence of hypertension was calculated by age-adjusted logistical regression analysis, in which the odds ratio (OR) and 95% confidence intervals (CIs) were calculated using multivariate analysis. A two-tailed P value of less than 0.05 was considered significant.

RESULTS

General characteristics

Characteristics of the sample are summarized in Table 1. The sample comprised 3720 participants; out of these, 3612 (97.1%) were Caucasians and 1955 (52.6%) were women. The mean age was 49.1 ± 18.0 (range 18–90 years). Approximately 32% of men and 37% of women reported family histories of hypertension. The overall prevalence of hypertension was 42.2%, which is slightly but significantly higher ($P < 0.0001$) in men (44.4%) than in women (40.2%). One-fifth of the participants were obese. In both sexes, overweight and obese participants, abdominal adiposity as well as nonsmokers or ex-smokers and participants with lower level of education were significantly more likely to have hypertension. History of hypertension in both parents was significantly more common in hypertensive patients than in normotensive individuals. As shown in Table 1, in both sexes, hypertension, self-reported diabetes, dyslipidemia and previous cardiovascular events were two to five times more common in patients with hypertension (all $P < 0.001$) than in patients with normotension. Overall prevalence of albuminuria at least 30 mg/24 h was 14.3% (mean 13.2 ± 47.6 mg/24 h), being 16.4% in hypertensive patients and 12.6% in normotensive individuals ($P < 0.01$).

Mean blood pressure values

The age and sex-specific mean BP levels for the total populations and for the subgroups of normotensive individuals, treated and untreated hypertensive patients are shown in Table 2. Overall, the mean BP was

TABLE 1. Characteristics of participants ($n = 3720$) in the national sample survey of hypertension in Portugal (2012)

Variable	Men, *n* (%)			Women, *n* (%)		
	All	NTs	HTs	All	NTs	HTs
Total	1765 (47.4)	982 (55.6)	783 (44.4)	1955 (52.6)	1170 (59.8)	785 (40.2)
Age (years) mean ± SD, 49.0 ± 18.0						
18–34	525 (29.7)	472 (48.1)	53 (6.8)[a]	521 (26.6)	503 (43.0)	18 (2.3)[a]
35–64	854 (48.4)	413 (42.1)	441 (56.3)[a]	954 (48.8)	547 (46.8)	407 (51.8)[a]
>64	386(21.9)	97 (9.8)	289 (36.9)[a]	480 (24.6)	120 (10.2)	360 (45.9)[a]
Educational level						
Less than 6 years of schooling	726 (41.2)	170 (17.3)	354 (45.3)[a]	844 (43,2)	253 (21.6)	461 (61.1)[a]
6–9 years of schooling	385 (21.8)	228 (23.2)	209 (26.8)	449 (23.0)	251 (21.5)	151 (20.0)
>9 years of schooling	652 (36.9)	584 (59.5)	218 (27.9)[a]	659 (33.8)	665 (56.9)	142 (18.9)[a]
Family history of hypertension						
No history	1202 (68.1)	699 (71.1)	503 (64.4)	1029 (52.6)	642 (54.9)	387 (49.5)
History 1 parent	469 (26.6)	249 (25.3)	220 (28.2)	708 (36.2)	425 (36.3)	283 (36.2)
History 2 parents	92 (5.2)	32 (3.3)	60 (7.7)[a]	215 (11.0)	103 (8.8)	112 (14.3)[a]
Smoking status						
Smoker	285 (16.1)	285 (29.0)	108 (13.8)[a]	276 (14.1)	229 (19.6)	47 (6.0)[a]
Nonsmoker	776 (44.0)	473 (48.2)	303 (38.7)	1463 (74.8)	795 (67.9)	668 (85.1)
Ex-smoker	586 (33.8)	224 (22.8)	372 (47.5)[a]	216 (11.1)	146 (12.5)	70 (8.9)[a]
BMI (kg/m^2) mean ± SD, 27.1 ± 4.9						
BMI ≥25 and <30 (overweight)	574 (32.6)	269 (27.4)	305 (39.0)[a]	581 (29.7)	274 (23.4)	307 (39.1)[a]
BMI ≥30 (obese)	361 (20.5)	131 (13.4)	250 (31.9)[a]	399 (20.4)	172 (14.7)	227 (29.0)[a]
Waist circumference (cm) mean ± SD. 89.1 ± 11.2						
Abdominal fat (women ≥88, men ≥102)	504 (28.5)	188 (19.1)	316 (40.3)[a]	776 (39.7)	391 (33.4)	385 (49.0)[a]
Diabetes	201 (11.4)	53 (5.5)	148 (19.5)[a]	180 (9.2)	30 (2.6)	150 (19.6)[a]
Dislipidemia	513 (29.1)	195 (21.2)	318 (42.9)[a]	723 (37.0)	307 (27.3)	416 (56.3)[a]
Cardiovascular events						
Previous stroke [n (%)]	55 (3.1)	12 (1.2)	43 (5.5)[a]	63 (3.3)	13 (1.1)	50 (6.1)[a]
Previous coronary disease [*n* (%)]	67 (3.8)	16 (1.6)	51 (6.1)[a]	62 (3.3)	13 (1.1)	49 (6.0)[a]
Peripheral artery disease [*n* (%)]	46 (2.6)	13 (1.3)	33 (4.3)[a]	116 (6.4)	47 (4.0)	69 (9.0)[a]
Cardiac failure, [*n* (%)]	61 (3.5)	17 (1.7)	44 (5.7)[a]	80 (4,3)	27 (2.3)	53 (6.9)[a]
Albuminuria ≥30 mg/24 h [*n* (%)]	193 (13.3)	80 (10.0)	113 (17.2)[a]	249 (15.2)	113 (11.6)	136 (20.1)[a]
24-h urinary samples validated (*n*)	1234	652	582	1344	773	561
Urinary sodium excretion (mmol/24 h) mean ± SD	185.6 ± 66.7	179.2 ± 63.8	189.5 ± 65.1[a]	178.0 ± 62.3[b]	176.6 ± 63.9	182.1 ± 63.9
Urinary potassium excretion (mmol/24 h) mean ± SD	76.4 ± 28.1	75.2 ± 28.1	77.6 ± 26.5	75.4 ± 25.7	73.9 ± 25.0	77.4 ± 26.0[a]

HTs, hypertensive patients; NTs, normotensive individuals.
[a]$P < 0.02$ significantly different from NTs, same sex.
[b]$P < 0.02$ significantly different women vs. men.

127.4/74.6 ± 17.7/10.5 mmHg. In men, BP was on average 7.7/2.2 mmHg higher compared with women ($P < 0.001$). SBP increased progressively with age in men and women. DBP increased with age only until 35–64 years, thereby becoming lower than that group in the older ages (>65 years); this was identical on both sexes. In the normotensive individuals, BP was on average 16.9/5.4 mmHg lower than that of treated hypertensive patients and 29.1/14.2 mmHg lower than that of untreated hypertensive patients. Treated and untreated hypertensive

TABLE 2. Mean SBP and DBP (values in mm Hg) in the adult population, aged 18–90 years, by hypertension status and in Portugal in 2012

Age	Normotensives		Treated hypertensive patients		Untreated hypertensive patients		Total	
	SBP	DBP	SBP	DBP	SBP	DBP	SBP	DBP
Men	122.9 ± 9.2	71.7 ± 8.3	139.1 ± 18.1	78.2 ± 11.5	149.2 ± 11.1	86.1 ± 10.4	131.5 ± 16.3	75.7 ± 10.9
<35 years	121.8 ± 9.1	69.5 ± 7.9	135.5 ± 15.1	80.0 ± 12.6	145.9 ± 7.3	82.6 ± 8.8	123.9 ± 11.4	70.8 ± 8.9
35–64 years	123.6 ± 8.8	74.9 ± 7.3	138.1 ± 17.1	81.6 ± 11.2	149.4 ± 12.1	89.2 ± 10.1	133.2 ± 16.2	79.8 ± 10.7
>64 years	124.8 ± 10.5	69.7 ± 8.9	140.5 ± 19.4	73.9 ± 10.4	150.9 ± 10.4	80.2 ± 9.0	138.1 ± 18.4	73.5 ± 10.4
Women	114.9 ± 10.9	70.8 ± 8.0	134.4 ± 18.7	75.9 ± 10.9	147.9 ± 11.7	84.8 ± 9.6	123.8 ± 18.0	73.5 ± 10.1
<35 years	110.6 ± 9.2	69.1 ± 7.6	123.0 ± 15.7	79.5 ± 9.3	137.4 ± 12.4	89.5 ± 9.9	111.2 ± 10.1	69.2 ± 8.2
35–64 years	116.7 ± 10.9	72.9 ± 7.7	131.3 ± 17.3	79.3 ± 10.6	147.4 ± 11.7	87.2 ± 9.1	124.5 ± 16.7	76.4 ± 10.0
>64 years	125.1 ± 9.3	70.2 ± 8.4	137.9 ± 19.8	72.6 ± 10.3	150.8 ± 10.7	78.6 ± 7.7	135.9 ± 18.5	72.5 ± 9.9
Total	119.6 ± 10.2	72.5 ± 8.1	136.5 ± 18.7	76.9 ± 11.3	148.7 ± 11.3	85.7 ± 10.1	127.4 ± 17.7	74.6 ± 10.5
<35 years	116.0 ± 10.7	69.1 ± 7.8	129.2 ± 16.3	79.8 ± 10.7	144.8 ± 8.6	83.6 ± 9.1	117.6 ± 12.5	70.0 ± 8.6
35–64 years	119.7 ± 10.6	73.8 ± 7.6	134.5 ± 17.5	80.4 ± 10.9	148.7 ± 11.9	88.5 ± 9.7	128.6 ± 17.0	78.6 ± 10.5
>64 years	125.0 ± 9.8	69.5 ± 8.6	139.0 ± 19.6	73.1 ± 10.4	150.9 ± 10.5	79.5 ± 8.5	136.8 ± 18.5	72.9 ± 10.1
Total in 2003 (ref. [7])	120.5 ± 0.2	75.1 ± 0.1	152.1 ± 0.8	85.3 ± 0.4	151.9 ± 0.4	88.9 ± 0.3	134.7 ± 0.2	80.4 ± 0.1

Data of total population is compared with that of a similar study done in Portugal in 2003 in a comparable population. Data of ref [7] are mean ± s.e.m.

patients differ on their BP by 12.2/8.8 mmHg. Table 2 also shows comparative values from the previous survey performed in Portugal in 2003 [7]. From 2003 to 2012, the mean BP decreased by 7.3/5.8 mmHg in the overall adult population in Portugal. Such a decrease in average BP was 0.9/2.6 mmHg in the normotensive population and 12.4/8.0 mmHg in the hypertensive population.

Prevalence of hypertension, awareness, treatment and control

The prevalence of hypertension and proportions of participants with hypertension who were aware of their hypertensive condition, and were treated with antihypertensive drugs, and were both treated and controlled are presented in Table 3. Prevalence of hypertension increased significantly with advancing age, and it was greater in men compared with women in groups aged below 64 years, but not beyond that age. In the youngest age group (18–34 years), hypertension was present in 6.8% of the population, whereas the prevalence rate was 74.9% in the oldest age group aged above 64 years. As also shown in Fig. 1, only in patients aged above 70 years, the prevalence of hypertension was even higher in women than in men. Overall, 76.6% of those with hypertension were aware of the condition and 74.9% were treated. Globally, among patients treated, 55.7% were controlled and in the overall hypertensive population the rate of control was 42.5%. In all of these, higher percentages of awareness, treatment and control were observed in women than in men. In all the age groups, rates of awareness, treatment and control of hypertension increased significantly with age in both sexes. Analysis of antihypertensive therapy of hypertensive patients showed that among patients ($n = 668$) with hypertension controlled, 262 (39.2%) patients were on monotherapy and 377 (56.4%) were on combination therapy (280 with two drugs and the remaining 64 with three or more drugs). In contrast, in patients with uncontrolled hypertension, 266 (52.5%) of them were on monotherapy and 241 (47.6%) patients were on combination therapy (191 with two drugs and the remaining 50 with three or more drugs), that is, combination therapy was present in a significantly ($P < 0.02$) lower percentage than that of controlled patients. As shown in Table 2, overall rates of prevalence, awareness, treatment and control of hypertension found in the present study were compared with that found in 2003. As shown, the rates of awareness and treatment almost doubled from 2003 to 2012 and the rate of patients with adequate BP control increased by 3.8 times in this interval. In the overall untreated hypertensive population, hypertension awareness rate was 6.9% (27/394) (Fig. 2).

Particularities and comorbidities

Overall, the percentage distribution of the population by the grades of BP according to guidelines [12] was 1251 patients (33.6%) with normal BP (SBP 120–129 or DBP 80–84 mmHg), 1568 patients (42.2%) with high normal blood pressure (SBP 130–139 or DBP 85–89 mmHg), 469 patients (12.6%) with hypertension grade 1 (SBP 140–159 or DBP 90–99 mmHg), 395 patients (10.6%) with hypertension grade 2 (SBP 160–179 or DBP 100–109 mmHg) and

TABLE 3. Prevalence of hypertension and percentage of individuals with hypertension who are aware, treated and controlled, and percentage of treated hypertensive patients who are controlled in the adult population, aged 18–90 years, in Portugal in 2012

Age	All hypertensive patients ($n = 1568$)					Hypertensive men ($n = 783$)					Hypertensive women ($n = 785$)				
	Prevalence	Aware	Treated	Controlled	Controlled treated	Prevalence	Aware	Treated	Controlled	Controlled treated	Prevalence	Aware	Treated	Controlled	Controlled treated
Total	42.2%	76.6%	74.9%	42.5%	55.7%	44.4%	69.5%	67.7%	34.7%	51.3%	40.2%	83.7%	82.0%	50.3%	61.3%
n	(1568/3720)	(1201/1568)	(1174/1568)	(667/1568)	(667/1174)	(783/1765)	(544/783)	(530/783)	(272/783)	(272/530)	(785/1955)	(657/785)	(644/785)	(395/785)	(395/644)
<35 years	6.8%	31.0%	29.5%	18.3%	61.9%	10.0%	20.8%	20.8%	9.4%	45.5%	3.5%	61.1%	55.5%	44.4%	80.0%
n	(71/1046)	(22/71)	(21/71)	(13/71)	(13/21)	(53/525)	(11/53)	(11/53)	(5/53)	(5/11)	(18/521)	(11/18)	(10/18)	(8/18)	(8/10)
35–64 years	46.9%	73.1%	70.9%	42.7%	60.2%	51.6%	67.3%	64.9%	33.8%	52.1%	42.7%	79.4%	77.4%	52.3%	67.6%
n	(848/1808)	(620/848)	(601/848)	(362/848)	(362/601)	(441/854)	(297/441)	(285/441)	(149/441)	(149/285)	(407/954)	(323/407)	(315/407)	(213/407)	(213/315)
>64 years	74.9%	86,1	85.1%	45.0%	52.9%	74.9%	81.7%	80.6%	40.8%	50.6%	75.0%	89.7%	88.6%	48.3%	54.5%
n	(649/866)	(559/649)	(552/649)	(292/649)	(292/552)	(289/386)	(236/289)	(233/289)	(118/289)	(118/233)	(360/480)	(323/360)	(319/360)	(174/360)	(174/319)
Total 2003 (ref [7])	42.1%	45.7%	38.9%	11.2%	28.6%	49.5%	36.7%	30.6%	7.2%	23.4%	38.9%	56.1%	48.1%	15.4%	32.1%

Data of total population is compared with that of a similar study done in Portugal in 2003 in a comparable population.

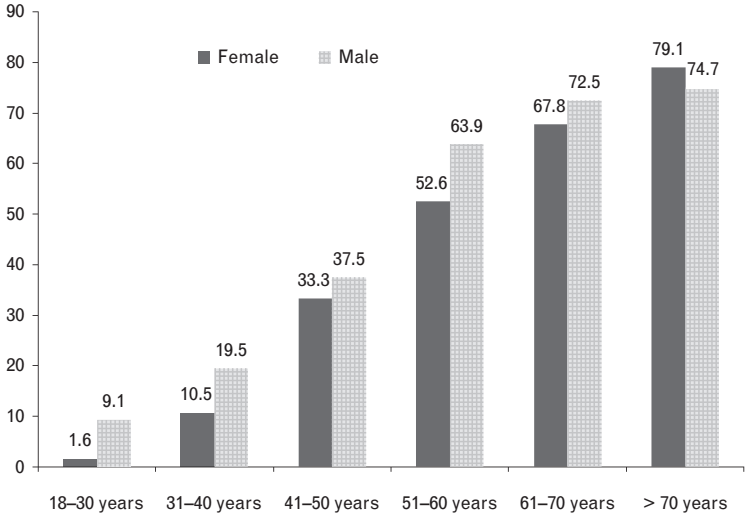

FIGURE 1 Prevalence of hypertension by sex and age (years) among the Portuguese adult population.

37 patients (1.0%) with hypertension grade 3 (SBP ≥180 or DBP ≥110 mmHg). In the hypertensive population, pulse pressure was significantly different [analysis of variance (ANOVA), $P < 0.001$] among those aged above 64 years (66.7 ± 16.1 mmHg), those aged 35–64 years (56.8 ± 13.2 mmHg) and those aged below 35 years (57.5 ± 13.1 mmHg). Overall prevalence of ISH was 15.1% ($n = 561$) – 14% in women and 17.1% in men. According to the age group, the prevalence of ISH was 3.1% ($n = 32$) in patients aged below 35 years, 12.2% ($n = 220$) in those aged 35–64 years and 35.7% ($n = 309$) in those aged above 64 years (ANOVA, $P < 0.001$). Among all hypertensive patients under treatment ($n = 1175$), apparent resistant hypertension was diagnosed in 94 (8%), 70 of whom (74.5%) were uncontrolled with three or more antihypertensive drugs, including a diuretic, and 24 (25.5%) were controlled with four or more antihypertensive drugs. Multivariate logistic regression analysis showed that only age (OR 1.177, 95% CI 1.171–1.183), BMI (OR 1.150, 95% CI 1.129–1.172) and female sex (OR 0.680, 95% CI

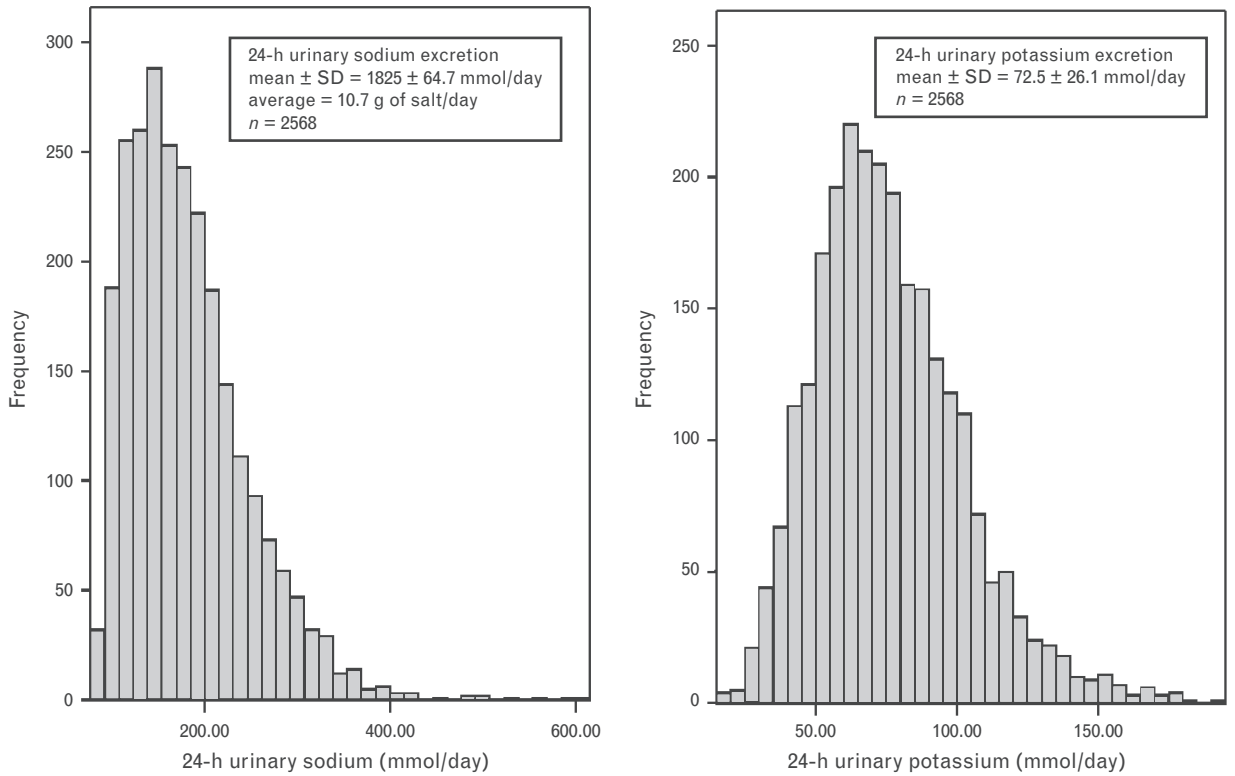

FIGURE 2 Bar graphs showing distribution of urinary excretion of (a) sodium and (b) potassium in 24-h urinary samples validated by urinary creatinine levels in the Portuguese adult population.

0.578–0.801) were independently associated with the prevalence of hypertension (all $P < 0.001$), whereas factors such as waist circumference, educational level, alcohol drinking and urinary sodium excretion were not independently associated on that relationship, that is, after adjustment for age and sex.

Blood pressure at visit 2

From all participants admitted to the visit 1, 3143 (84.4% of total) agreed to return to visit 2, after 10–15 days, providing assurance that any ongoing therapy has not been changed within this interval. This population was aged 50.4 ± 0.3 years, 52.0% were women, and prevalence of hypertension was 43.9% (1380/3243) based on data of visit 1. In that population, net BP decreased from $128.1/74.9 \pm 17.6/10.5$ mmHg at visit 1 to $124.1/72.8 \pm 16.2/10.3$ mmHg at visit 2 (net BP reduction of $4.1/2.1 \pm 11.2/6.8$ mmHg) (all $P < 0.0001$), and mean heart rate was 72.9 ± 11.2 at visit 1 and 73.2 ± 11.4 beats/min at visit 2 ($P = 0.10$). In this population, the rate of controlled hypertension increased from 42.5% (587/1380) at visit 1 to 56.9% (786/1380) at visit 2 ($P < 0.01$).

Twenty-four-hour urine collection

From all patients ($n = 3143$) who came to a second visit with the instructions of bringing their 24-h urine sample collection, 3032 complied with these requirements. Out of these, 2568 urine samples fulfilled the validation criteria (1234 from men and 1344 from women). Out of the remaining, 414 did not fulfill the validation criteria based on urinary creatinine levels and 50 were eliminated because of codification errors in the central lab. On average, for all the population, 24h-UNa was 182.5 ± 64.7 mmol/24 h (corresponding to average daily intake of 4.2 g of sodium and to 10.7 g of salt); 24h-UNa was significantly higher ($P < 0.02$) in the hypertensive patients (185.4 ± 64.8 mmol/24 h, $n = 1143$) than in the normotensive individuals (177.8 ± 64.5 mmol/24 h, $n = 1425$). As shown in Table 1, 24-h UNa was also higher in men than in women, and higher in hypertensive men than in normotensive men. Among the hypertensive patients, 24-h UNa did not differ between untreated patients (186.5 ± 64.7 mmol/24 h), treated and controlled (188.1 ± 66.4 mmol/24 h), and treated but uncontrolled (184.9 ± 62.5 mmol/24 h). Also, for the entire population, 24-h potassium excretion (24h-UK) was 75.9 ± 26.1 mmol/24 h, which was significantly higher ($P < 0.02$) in the hypertensive patients (77.5 ± 26.5 mmol/24 h, $n = 1143$) than in the normotensive individuals (74.4 ± 25.7 mmol/24 h, $n = 1425$). As shown in Table 1, 24-h UK was higher in men than in women, and higher in hypertensive men than in normotensive men. Significant correlation was observed between 24-h UNa and 24-h UK (0.572, $P < 0.001$, $n = 2565$), whereas fair although significant positive correlations were observed between 24-h UNa and BMI ($r = 0.099$, $P = 0.001$, $n = 2565$), SBP ($r = 0.051$, $P = 0.010$, $n = 2565$) and age ($r = 0.081$, $P = 0.001$, $n = 2565$). The ratio 24h-UNa/24h-UK was 2.53 ± 0.86 in normotensive individuals, that is similar to that of hypertensive patients (2.55 ± 0.98). From all valid 24-h urinary samples ($n = 2568$), only 110 (4.3%), that is, 65 (4.6%) in the normotensive group and 45 (3.9%) in the hypertensive group fulfilled the recommendations of daily sodium intake of less than 100 mmol/day.

DISCUSSION

The present Portuguese HYpertension and SAlt (PHYSA) study provides the first national data simultaneously on prevalence, awareness and control of hypertension, and on salt intake from validated 24-h urinary samples in a statistically representative sample of the adult population living in Portugal (continental). Also, the study was strengthened by the inclusion of detailed information on habits, socio-demographic variables and ongoing medication. In another two points, this survey was particularly innovative as it included a second evaluation of BP during a further visit 2 weeks after, and because it permitted to explore the decade trend on prevalence, awareness and control of hypertension by comparison with a study done in 2003 [7]. Because Portugal has a considerably high cerebrovascular mortality compared with other western countries [17], data on BP control assume particular importance.

Prevalence

We found a global prevalence of hypertension of 42.2%, which is similar to the 42.1% previously recorded in Portugal [7] (in 2003). This shows that the global burden of hypertension is substantial and a cause of major health concern. The prevalence of hypertension in adult populations worldwide varies from 5.2 to 70.7% [18]. Compared with other population-based studies done in middle-aged adults, in our study, the prevalence and awareness of hypertension were within the intervals of the rates (33–56%) reported in European countries [19–22], but higher than the 26–31% rates reported in China [23], India [24] Korea [25], Jordan [26] Canada, and the United States [20]. Variations in prevalence rates of hypertension by regions could be attributed to several factors including socioeconomic factors, differences in study designs and methodology of BP measurement. However, the greater prevalence of hypertension in our study than in USA could also be the result of our BP measurement on a single day, whereas in USA a diagnosis of hypertension is based on multiple BP measurements on different occasions [11]. In the present study, we based the definition of hypertension on three or two close measurements during one single day, not only because it has been an advisable procedure to be used in epidemiological surveys [4,27] but also in order to permit comparisons with data from other data using the same methodology around the world [7,19–25,28], including that done in 2003 in Portugal [7]. The prevalence of hypertension in our participants older than 34 years was similar to that observed in the Portuguese study in 2003 [7]. Consistent with the findings of several studies, the prevalence of hypertension in our study was higher in older persons [7,20,21,23–25] and in men than in women [7,21,23–25,28] at least before 70 years of age, but no longer after that age. Also, it was higher in nonsmokers than in smokers [25], as well as in individuals with lower education than in those with higher education levels [24,25,28]. Also

in line with data from other studies [7,21,23–25,28], the prevalence of hypertension was positively associated with BMI. In our study, nearly half of the population was overweight or obese, and obesity was the modifying factor most strongly correlated with hypertension. Recent data have suggested that in Portugal, obesity has markedly increased in the past decade [29]. Because weight reduction has been shown to lower the risk of hypertension in more than 50% over the long term [30], weight loss must be considered highly important for our obese population as a part of the strategy in primary prevention of hypertension. Although some variables were positively associated with the risk of hypertension, in multivariate regression analysis after adjustment for potential confounders, only increasing age and BMI were positively and independently correlated with hypertension. Thus, different from the data of other studies [23,25,28], in our study, the influence of all other factors included in the model such as education status, smoking, drinking, salt intake and sex lost independent statistical significance on the risk of hypertension. This may probably represent the particular strength of the determinant relation between age and obesity with hypertension.

As described in other studies [7,25], we found a low (3.1%) prevalence of ISH in participants aged under 35 years, which increased with age, reaching a prevalence of 35.7% in the older (>64 years) patients. Among hypertensive patients under medication, we found a prevalence of apparent resistant hypertension of 8.1%, which is similar to data from another population study [31]. As already stated, and for reasons of comparability, we decided to define hypertension on the basis of the evaluation of BP in a single day. However, it is well known that BP can decrease markedly over repeated visits [27], and recommendations on hypertension require that the definition should be based on two to three determinations on different occasions and not only on a single day [11]. In fact, as in most of the epidemiological studies, when definition of hypertension is based on measurements done in a single day, the appropriate correction for the regression–dilution bias is lacking. Because of that, we introduced in our survey a second day of evaluation of BP. From visit 1 to visit 2, there was a global reduction in average BP of 4.1/2.1 mmHg along with an additional increase of the rate of control of hypertension of 14.4%. Our data suggest that the evaluation of hypertension in only a single day, even when based on three measurements, may underestimate the rate of control of hypertension and also overestimate the prevalence of hypertension.

Awareness, treatment and control

Overall awareness of hypertension was 76.6% in the present study, which is within the interval of rates (63–82.5%) recently reported in other countries [19,21,25,32], but higher than that found in China (45%) [28], India (55.6%) [24] and Korea [25]. As in other studies [7,23–26], we found a higher prevalence of hypertension awareness in women than in men, along with a better control rate of hypertension in women. Age was also positively associated with awareness of hypertension, particularly among women. Previous authors [33] have argued that higher rates of awareness in women may be related to the privileged relationship women have with healthcare facilities because of maternal and childcare-oriented programs. Also as described [24,25,28], in our study, rates of awareness, treatment and control were greater in patients with hypertension aged 64 years or older and 35–64 vs. those aged 18–34 years. In both situations, higher awareness could also be a result of a higher treatment-seeking behavior. Our finding coincides with reports from other studies which state that adults aged under 39 years were less aware of hypertension than older individuals [23,24,26,28]. As expected from other studies [23,26,34], we found that control of hypertension was higher among older than among younger patients, and was also higher among women than men. The present study showed that three-quarters of the hypertensive population were treated. This rate is comparable to the 61.4–82.5% treatment rates reported in other countries [19,25,26,32]. We found that treatment and control rates increased with age as reported by others [25,26], suggesting that older patients may exhibit a better compliance with prescribed medicines than younger people. Also, we found a rate of control of hypertension among those receiving medication for hypertension of 55.6%, which is within the interval (35.1–66.4%) of control rates observed in other studies [7,25,32].

Evolution in hypertension status in Portugal (2003 to 2012)

Comparing with the previous survey done in Portugal [7], we found that from 2003 to 2012, the rate of awareness and treatment of hypertension almost doubled, despite a similar prevalence of hypertension, whereas the rate of control of hypertension increased by 3.8-folds. Other studies have reported an improvement of rates of treatment and control of hypertension over decades [21,35,36]. Particularly, in our study, the percentage of hypertensive patients under treatment who were controlled almost doubled from 2003 to 2012. These progresses may have been related with an increased use of antihypertensive medications, with new therapeutic approaches and with a general improvement of the information of the populations and of the health system. In the past decade several campaigns in Portugal were triggered, alerting the population to the importance of hypertension as a cause of disease. Also, there is a general belief that the population's access to primary healthcare has improved considerably in recent years. Concerning treatment, in our study, patients with adequate control of hypertension were more frequently treated with combination of antihypertensive drugs (65% being fixed combinations) than those with uncontrolled BP. Also, this is in accordance with other studies that reported an association of a more frequent use of drug combinations with a progressive increase in an adequate control of hypertension [37]. Again, this is in good agreement with European [12] and American [11] guidelines, particularly in regard to the recommendations of the need of a more frequent use of combinations of antihypertensive drugs as a way to reach the desirable hypertension control. Thus, our data suggest that Portugal has made important progress in the management of hypertension over the past decade, since not only the percentage of treated patients increased, but particularly the quality of the treatment was markedly improved. In

our study, hypertension control improved within 10 years despite adverse changes in obesity. It is important that the improvement in hypertension control from 2003 to 2012 in Portugal coincided with a significant reduction of SBP and DBP among patients with hypertension of around 12.4/8.0 mmHg on an average. On the basis of data from meta-analysis, we could estimate such a reduction of BP in the Portuguese population to be traduced in more than 20% reduction of stroke mortality in 10 years [38].

Particularities and comorbidities

In both sexes, hypertension was associated with an increased frequency of self-reported diabetes and dyslipidemia, and previous cardiovascular events were 2–5 times more common in patients with hypertension. Even with the limitations of self-reporting or therapy while assessing the presence of these comorbidities, the higher occurrence of these in the population with hypertension vs. normotensive individuals agrees with what has been largely shown [2].

Urinary sodium excretion

This was the first time that sodium intake was measured in a national sample in Portugal. Sodium and potassium excretion was measured in validated 24-h urinary samples. In the overall population, we showed that the average sodium intake was 182.5 mmol/day (estimated daily salt intake of 10.7 g/day), largely exceeding the international recommendations [11,12,39]. This is slightly lower than the values recorded under the same methodology in two pilot studies performed in small-sized populations in Portugal [14,15]. Hypertensive patients showed significantly higher sodium intake than normotensive persons. Also, we observed no difference in 24h-UNa between treated and nontreated hypertensive patients, and between hypertensive patients with controlled or uncontrolled hypertension. Men showed a higher sodium intake than women, which may be a consequence of a higher food and energy intake in men. Sodium excretion was correlated fairly, although significantly, with SBP, but associated in a higher degree of significance with BMI. These findings confirm data from other studies [15,40], showing a particular association of salt intake with indices of obesity. In our study, daily sodium excretion largely exceeded the recommendations not only in the overall population in both sexes but also both in the hypertensive as well as in the normotensive individuals. Since in the normotensive individuals, daily sodium intake was about double of that recommended, it may suggest that excessive intake of sodium is not a sufficient condition for the development of hypertension. In other words, this finding, along with the fact that correlation between salt excretion and BP was fair, may suggest that some degree of salt resistance may occur in the Portuguese population. Potassium intake may have some cardiovascular protective effect, and a 42 mmol/day higher average potassium intake has been associated with a 21% lower risk of stroke [41]. In our study, daily potassium intake was almost half of the recommended intake of 100 mmol/day and it followed in parallel with that of sodium intake, being higher in hypertensive patients than normotensive individuals and correlating with BMI. Such a trend to a positive association between sodium intake, potassium intake and BMI confirms data from other studies [40] and may be explained by greater food and calorie intake by overweight individuals that include not only salt-rich food but also with respect to potassium intake, a higher consumption of fruits and vegetables. The mean 24-h urinary sodium/potassium was around three times higher than the desirable levels of 0.85 either in men or women, as well as in the subgroups of hypertensive and normotensive individuals.

Strengths and limitations

Our study has strengths and limitations. The strengths include the population-based multistage-stratified cluster sampling design which permits a reasonable generalization of our findings to the Portuguese adult population. This was the first survey done in Portugal, measuring sodium intake with a valid methodology in a representative sample of the adult population. Also, the study was strengthened by its capacity to highlight the trend observed in the past decade of prevalence, awareness and control of hypertension. Finally, this survey was particularly innovative as it included a 2-week apart second day BP evaluation, thereby drawing attention to the limitations of BP measured on a single day on the evaluation of prevalence and control of hypertension. Our study shares the general limitation of any cross-sectional study since we cannot make causal associations. Also, since for comparative purposes and epidemiological consistence, we diagnosed hypertension based on a single visit, it is plausible that we have overestimated the prevalence and underestimated the control rate of hypertension. Because the diagnosis of hypertension was based on awareness, labeling and ongoing treatment, we were not able to measure accurately the influence of the second visit on prevalence of hypertension. However, an overestimated prevalence on visit 1 was in fact suggested by the increase in rate of hypertension control that was observed from the first to the second visit 2 weeks after. Although in the present survey all the examinations were conducted throughout the year, we cannot exclude that some seasonal variations of BP may have occurred between groups. Another limitation may rely on some inaccuracy of self-reporting data. Despite our efforts to select only valid 24-h urinary samples, we share the general limitation of one single 24-h urine collection while measuring the daily sodium and potassium excretion.

Health implications

Our study may have public and health implications. Although a favorable evolution in awareness, treatment and control of hypertension was observed in Portugal from 2003 to the present study, it should be emphasized that a significant further improvement is still needed and that should be a major public health issue. This should include an education program including mass media approaches, trying to combat against overweight and high salt intake. We have in mind that in Finland one of the main contributing factors that were considered responsible for the reduction of BP levels observed

during 1982–2002 was the decrease in mean sodium intake [21].

In conclusion, this large national epidemiological survey representative of Portuguese adult population showed that hypertension prevalence among Portuguese adults remained high (around 42%) and stable in the past decade, but proportions of awareness, treatment and control of hypertension improved significantly despite adverse increase in obesity. Since there was strong association between hypertension and BMI, this study reinforces the need of population-wide measures to address the epidemic problem of overweight in Portugal as a way to prevent and treat high BP. The significant reduction of BP found after a second visit enable to conclude that epidemiological surveys based on BP measured on a single day probably overestimated prevalence of hypertension and underestimated the rate of control. Our study measured for the first time the sodium excretion in the overall population, showing that daily salt consumption is almost double than the WHO recommendations and is strongly related to obesity.

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Conflicts of interest

None of the authors have any financial or nonfinancial competing interests concerning the present study.

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Reviewers' Summary Evaluations

Referee 1

The primary strength of this study is the method in which it was conducted and then repeated after a 10-year period. This allows a rigorous statistical analysis. It is well written and very clear in how the data lead to their conclusions. The major weakness is that hypertension was diagnosed based on a single visit and their correlations between salt intake and blood pressure require further study.

The strengths of the study are the novelty, the appropriate methodological approach, the elegance of the protocols that are clear, and the conclusion of the study that is well supported by the data.

Referee 2

The prevalence of hypertension has not changed, therefore, there seems to be a large room for improvement for the prevention of hypertension. The high prevalence of hypertension in the elderly may be caused by an excess of salt intake, which can accelerate the age-related hypertension. However, there was no significant association between urinary sodium excretion and blood pressure in this study. This may be partly caused by the poor reproducibility of casual blood pressure. Further studies based on home or ambulatory blood pressure are needed to clarify this, and also the prevalence of white-coat hypertension or masked hypertension.