Thresholds for Conventional and Home Blood Pressure by Sex and Age in 5018 Participants From 5 Populations

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Abstract**—**Whether blood pressure thresholds for hypertension should differ according to sex or age remains debated. We did a subject-level meta-analysis of 5018 people untreated for hypertension and randomly recruited from 5 populations (women, 56.7%; ≥60 years, 42.3%). We used multivariable-adjusted Cox regression and a bootstrap procedure to determine home blood pressure (HBP) levels yielding 10-year cardiovascular risks similar to those associated with established systolic/diastolic thresholds (140–160/80–100 mm Hg) for the conventional blood pressure (CBP). Conversely, we estimated CBP thresholds providing 10-year cardiovascular risks similar to those associated established HBP levels (125–135/80–85 mm Hg). All analyses were stratified for sex and age (<60 versus ≥60 years). During 8.3 years (median), 414 participants experienced a cardiovascular event. The sex differences between HBP thresholds derived from CBP and between CBP thresholds derived from HBP were all nonsignificant (*P*≥0.24), ranging from −4.6 to 3.6 mm Hg systolic and from −4.3 to 2.1 mm Hg diastolic. The age differences between HBP thresholds derived from CBP and between CBP thresholds derived from HBP ranged from −6.7 to 8.4 mm Hg systolic and from −1.9 to 1.7 mm Hg diastolic and were nonsignificant (*P*≥0.08), except for HBP thresholds derived from CBP levels of 140 mm Hg systolic and 80 mm Hg diastolic (*P*≤0.04). Sensitivity analyses based on cardiac or cerebrovascular complications were confirmatory. In conclusion, our findings based on outcome-driven criteria support contemporary guidelines that propose single blood pressure thresholds that can be indiscriminately applied in both sexes and across the age range. **(*Hypertension*. 2014;64:695-701.)** • **Online Data Supplement**

Key Words: aged ■ classification ■ home blood pressure monitoring ■ self blood pressure monitoring ■ population ■ women

Hypertension causes worldwide an estimated 9.4 million deaths per year, more than half of the estimated 17 million cardiovascular deaths.[1] Hypertension firmly remains the strongest modifiable cardiovascular risk factor. For diagnosis and management of hypertension, several guidelines[2,3] recommended thresholds for blood pressure that are applicable irrespective of sex or age. A recent analysis[4] of the relationship between adverse cardiovascular outcomes and systolic blood pressure demonstrated that the risk increased more in women than in men, thereby revealing a largely unused potential for cardiovascular prevention in women. The 2014 Evidence-Based Guideline for the Management of High Blood Pressure in Adult proposed 150 mm Hg instead of 140 mm Hg as operational threshold to start and adjust drug treatment in older patients with hypertension.[5] Similarly, the 2013 European guidelines proposed higher thresholds for the elderly (≥80 years) than for younger adults.[6] This recommendations[5] revived the controversy on whether blood pressure thresholds should differ according to age or not.[7] We used the International Database of Home Blood Pressure in Relation to

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Cardiovascular Outcome[8] to investigate whether sex and age should be accounted for in deriving outcome-driven blood pressure thresholds. To ascertain consistency in our conclusions, we applied a 2-pronged approach. First, we derived thresholds for the home blood pressure (HBP) that yielded risks similar to long established thresholds for the conventional blood pressure (CBP). Next, we determined thresholds for the CBP yielding risks similar to generally accepted thresholds for the HBP. To address the research question at hand, we stratified our analyses by sex and age.

Methods

Study Participants

The International Database of Home Blood Pressure in Relation to Cardiovascular Outcome databases include studies involving a random population sample with longitudinal follow-up of fatal and nonfatal cardiovascular outcomes.[8] At the time of writing this report, we collected data from 7 prospective studies (8912 participants).[9–15] For the present analysis, we discarded 2159 people (Figure) because data on cause-specific mortality were unavailable[13] or because the study participants were referred patients instead of a population sample.[12] In the 5 population cohorts, included in the present analysis, the participation rate weighted for sample size was 57.3%.[16] Of the remaining 6753 participants, we excluded 1735 because <2 measurements were available to characterize the CBP (n=266) or HBP (n=18) or because participants were on antihypertensive drug treatment at baseline (n=1465). Therefore, the number of participants statistically analyzed totaled 5018, comprising 2010 inhabitants of Ohasama, Japan,[11] 1605 Finns representing a nationwide sample,[10] 476 inhabitants of the Tsurugaya district, Sendai, Japan,[14] 356 inhabitants of Montevideo, Uruguay,[9] and 571 inhabitants of Didima, Greece.[15] Characteristics of the participants excluded from the analysis seem in Table S1 in the online-only Data Supplement. All studies received ethical approval and participants gave written informed consent.

Blood Pressure Measurement

The CBP was measured twice by a standard mercury sphygmomanometer or a validated automated device using the appropriate cuff size after the participants had rested for ≥2 minutes.[8] For analysis, these 2 readings were averaged. We categorized the CBP according current guidelines.[2,3,6] The established diagnostic levels were 120, 130, 140, and 160 mm Hg systolic and 80, 85, 90, and 100 mm Hg diastolic. HBP was measured with validated automated devices, using the appropriate cuff size, after 2 to 5 minutes rest. For analysis, all HBP readings of each participant were averaged. In our analysis, we considered levels of 125, 130, and 135 mm Hg systolic and 80 and 85 mm Hg diastolic as thresholds for the HBP.

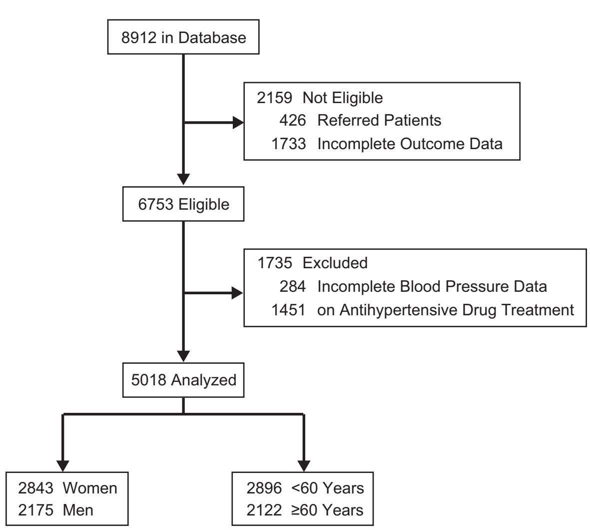

Figure. Flow chart of study participants.

Other Measurements

In all cohorts, questionnaires were used to obtain detailed information on each participant's medical history, intake of medications, and current smoking habits. Body mass index was body weight in kilograms divided by height in meters squared. Previous cardiovascular disease included cardiac and cerebrovascular disorders and peripheral vascular disease. Serum total cholesterol and blood glucose were determined by automated enzymatic methods on venous blood samples. Diabetes mellitus was a fasting or random blood glucose level of 7.0 mmol/L (126 mg/dL) or 11.1 mmol/L (200 mg/dL) or higher, use of antidiabetic drugs, a self-reported diagnosis, or diabetes mellitus documented in practice or hospital records.[17]

Ascertainment of Events

We ascertained vital status and incidence of fatal and nonfatal diseases from the appropriate sources in each country, as described in detail in a previous publication.[8] Fatal and nonfatal stroke did not include transient ischemic attacks. Coronary events encompassed death because of ischemic heart disease, sudden death, nonfatal myocardial infarction, and surgical and percutaneous coronary revascularization. Cardiac events comprised coronary end points, fatal and nonfatal heart failure, pacemaker implantation, and other cardiac deaths. The composite cardiovascular end point included cardiovascular mortality and cerebrovascular and cardiac end points. In all outcome analyses, we only considered the first event per participant.

Statistical Methods

For database management and statistical analysis, we used SAS software, version 9.3 (SAS Institute, Cary, NC). We compared means and proportions by the large-sample z test and by the χ^2 statistic, respectively. Statistical significance was an α-level of <0.05 on 2-sided tests. We interpolated missing values of body mass index (n=382) and serum cholesterol (n=133) from the regression slope on age after stratification for cohort and sex. In participants with unknown smoking habits (n=19), we set the design variable to the cohort- and sex-specific mean of the codes (0, 1). As described elsewhere,[8] while stratifying for sex and 10-year age groups, we extrapolated serum cholesterol for the Didima participants[15] from the levels observed in the ATTICA study,[18,19] which included a population sample examined at the same time (2001–2002) and in the same geographical area as the Didima participants.

We calculated hazard ratios using Cox regression while adjusting for cohort, sex, age, body mass index, smoking, serum cholesterol, and history of cardiovascular disease and diabetes mellitus. We checked the proportional hazards assumption by the Kolmogorov-type supremum test. From the multivariable-adjusted Cox models, we extrapolated the 10-year risk of end points associated with given levels of CBP or HBP.

As described in detail elsewhere,[20,21] we derived thresholds yielding equivalent 10-year risks of an end point for the HBP (result) from the CBP (reference) and vice versa in 4 steps. First, we computed the 10-year incidence rates of end points from the reference blood pressure. Second, we computed the 10-year incidence rates of an end point associated with the blood pressure under investigation for blood pressure levels ranging from the 5th to 95th percentile using steps of 0.1 mm Hg. In a third step, we selected blood pressure levels of the blood pressure measurement under investigation (result) that were associated with similar 10-year risks as given levels of the reference measurement. Next, we calculated the bootstrap distribution[22] of the so-obtained new diagnostic thresholds by randomly resampling the study population 1000× with replacement, using the PROC SURVEYSELECT procedure, as implemented in the SAS package. For each new sample, we repeated the first 3 steps. We accounted for tied event times, caused by resampling with replacement, by the TIESEXACT option in the PROC PHREG procedure. Finally, we calculated the bootstrap point estimates and 95% confidence intervals of the new thresholds as the mean±(1.96×SE) of the bootstrap distribution.[22]

Results

Baseline Characteristics of Participants

The whole study population (n=5018) included 2843 (56.7%) women, 2175 (43.3%) White Europeans, 356 (7.1%) South Americans of White European descent, and 2486 (49.5%) Japanese. In the whole cohort, age averaged 57.1±13.6 years, ranging from 18.5 to 97.0 years. Blood pressure on conventional measurement averaged 129.3±17.4 mm Hg systolic and 77.9±11.5 mm Hg diastolic; for the self-measured blood pressure at home, these levels were 123.9±17.2 mm Hg and 74.9±9.8 mm Hg, respectively. At baseline, 1624 (32.4%) participants had hypertension.

Table 1 provides the baseline characteristics of the study population by sex and age group (<60 versus ≥60 years). All sex differences were significant (*P*≤0.028) with the exception of age (*P*=0.24). All of the differences between age groups were significant (*P*<0.001) except for diastolic blood pressure on conventional measurement (*P*=0.12) and serum cholesterol (*P*=0.63). Table S2 lists the characteristics of participants by cohort.

Incidence of End Points

In the overall study population, median follow-up was 8.3 years (5th–95th percentile interval, 4.7–16.8 years). During 46651 person-years of follow-up, 522 participants died (11.2 per 1000 person-years), 158 of a cardiovascular cause (3.4 per 1000 person-years). A fatal or nonfatal cardiovascular event occurred in 414 participants (8.9 per 1000 person-years), including 194 cardiac events (4.2 per 1000 person-years) and 225 strokes (4.8 per 1000 person-years). Women compared with men had consistently lower risk of a cardiovascular end point (Tables 2 and 3), a cardiac event (Tables S3 and S4), or stroke (Tables S5 and S6).

Thresholds for HBP Derived From CBP

Table 2 lists the thresholds of the HBP that yielded multivariable-adjusted 10-year risks of a cardiovascular end point similar to those associated with the established reference levels on CBP measurement. None of the newly derived HBP thresholds differed between sexes (*P*≥0.24) or between age groups (*P*≥0.12) with the exception of borderline significant age-group differences in the HBP thresholds between derived from CBP levels of 140 mm Hg systolic (younger versus older participants, 128.4 versus 132.7 mm Hg; *P*=0.031) and 80 mm Hg diastolic (younger versus older participants, 75.8 versus 77.7 mm Hg; *P*=0.044). The sex differences (women minus men) between the HBP thresholds ranged from –4.6 to 3.1 mm Hg systolic and from –4.3 to –0.2 mm Hg diastolic; the corresponding age-group differences (young minus old) ranged from –1.9 to –6.7 mm Hg systolic and from –1.9 to 0 mm Hg diastolic (Table 3). Sensitivity analyses based on cardiac events (Table S3) or stroke (Table S5) produced consistent results without significant differences in the thresholds for the HBP between sexes (*P*≥0.10) and age groups (*P*≥0.11), with the exception of the home thresholds for stroke risk corresponding with a conventional systolic blood pressure of 130 mm Hg in younger versus older participants (119.1 versus 128.8 mm Hg; *P*=0.019; Table S5).

Thresholds for CBP Derived From HBP

Table 4 lists the thresholds of the CBP that yielded multivariable-adjusted 10-year risks of a cardiovascular end point similar to those associated with given levels of the HBP. None of the derived thresholds for the CBP differed between sexes (*P*≥0.33) or between age groups (*P*≥0.08). The sex differences

Table 1. Baseline Characteristics Stratified by Sex and Age

	Sex		Age	
Characteristics	Women (n=2843)	Men (n=2175)	<60 y (n=2896)	≥60 y (n=2122)
No. with characteristics (%)				
Asian	1480 (52.1)	1006 (46.3)	1088 (37.6)	1398 (65.9)
Hypertension	832 (29.3)	792 (36.4)	713 (24.6)	911 (42.9)
Diabetes mellitus	157 (5.5)	170 (7.8)	124 (4.3)	203 (9.6)
Current smoking	317 (11.2)	831 (38.2)	796 (27.5)	352 (16.6)
Previous cardiovascular disease	129 (4.5)	200 (9.2)	73 (2.5)	256 (12.1)
Mean characteristic (±SD)				
Age, y	56.9±13.6	57.4±13.4	47.7±8.7	70.0±6.7
Body mass index, kg/m^2	25.0±4.3	25.3±3.8	25.4±4.1	24.8±4.1
Serum cholesterol, mmol/L	5.48±1.02	5.36±1.11	5.44±1.07	5.42±1.04
Conventional blood pressure, mm Hg				
Systolic blood pressure	129.0±20.5	133.3±18.4	125.7±17.7	138.0±20.1
Diastolic blood pressure	76.0±11.3	80.4±11.3	77.7±11.6	78.2±11.4
Home blood pressure, mm Hg				
Systolic blood pressure	121.4±17.7	127.2±15.9	118.4±14.8	131.5±17.4
Diastolic blood pressure	72.9±9.6	77.5±9.5	74.1±10.1	76.1±9.3

Hypertension was a conventional blood pressure of ≥140 mm Hg systolic or ≥90 mm Hg diastolic. None of the participants was on antihypertensive drug treatment. Diabetes mellitus was a fasting or random blood glucose concentration of ≥7.0 mmol/L or ≥11.1 mmol/L, use of antidiabetic drugs, a self-reported diagnosis, or diabetes mellitus documented in practice or hospital records. All sex differences were significant (*P*≤0.028) except for age (*P*=0.24). All age differences were significant (*P*<0.001) except for serum cholesterol (*P*=0.63) and diastolic blood pressure on conventional measurement (*P*=0.12).

Table 2. Home Blood Pressure Levels Yielding 10-Year Risks of a Cardiovascular End Point Equivalent to Given Levels of the Conventional Blood Pressure

Conventional Blood Pressure Level Used as Reference, mm Hg	Sex				Age			
	Women (n=2843)		Men (n=2175)		<60 y (n=2896)		≥60 y (n=2122)	
	Risk, %	Home Blood Pressure, mm Hg	Risk, %	Home Blood Pressure, mm Hg	Risk, %	Home Blood Pressure, mm Hg	Risk, %	Home Blood Pressure, mm Hg
Systolic								
120	3.3	117.7 (112.1–123.3)	7.6	114.6 (107.8–121.3)	2.1	115.1 (110.4–119.8)	13.1	117.1 (108.4–125.8)
130	3.6	123.9 (122.5–125.3)	8.8	122.7 (119.5–125.8)	2.5	121.8 (120.6–122.9)	14.6	124.9 (119.9–129.9)
140	4.1	130.1 (125.2–135.1)	10.1	130.8 (129.4–132.1)	3.0	128.4 (124.3–132.5)	16.3	132.7 (130.8–134.6)
160	5.1	142.2 (129.3–155.1)	13.6	146.8 (139.1–154.6)	4.3	141.5 (130.2–152.8)	20.2	148.2 (141.5–154.9)
Diastolic								
80	3.8	76.5 (71.8–81.2)	9.1	76.7 (75.0–78.5)	2.5	75.8 (74.2–77.5)	16.6	77.7 (76.3–79.1)
85	4.1	79.7 (71.8–87.6)	10.1	81.2 (79.6–82.8)	2.9	80.3 (76.3–84.3)	17.9	81.7 (77.7–85.7)
90	4.4	82.6 (72.4–92.8)	11.3	85.6 (81.9–89.3)	3.3	84.6 (78.7–90.5)	19.2	85.4 (79.9–91.0)
100	5.1	87.1 (74.9–99.2)	14.0	91.4 (88.6–94.1)	4.4	90.5 (84.6–96.4)	22.2	90.5 (85.8–95.2)

Risk refers to the 10-y risk of a cardiovascular end point standardized to the mean distribution of cohort, sex (only for analyses stratified by age), age, body mass index, smoking, cholesterol, previous cardiovascular disease, and diabetes mellitus in the whole study population. In addition, for analyses stratified by age, the risk estimates were standardized to average age within the 2 age groups. Point estimates and 95% confidence intervals were obtained from the bootstrap distribution of 1000 random samples of the study population with replacement (for further details, see Methods). There were no differences in the derived home blood pressure thresholds between sexes ($P \geq 0.24$) or between age groups ($P \geq 0.12$) with the exception of 140 mm Hg ($P=0.031$) and 80 mm Hg ($P=0.044$) in age strata.

(women minus men) between the CBP thresholds ranged from –0.7 to 3.6 mm Hg systolic and from 1.9 to 2.1 mm Hg diastolic; the corresponding age-group differences (young minus old) ranged from 6.1 to 8.4 mm Hg systolic and from 0.7 to 1.7 mm Hg diastolic. Sensitivity analyses based on cardiac events (Table S4) or stroke (Table S6) produced consistent results without significant differences in the thresholds for the HBP between sexes ($P \geq 0.19$) and age groups ($P \geq 0.052$).

Discussion

In a previous International Database of Home Blood Pressure in Relation to Cardiovascular Outcome publication,[21] we determined HBP thresholds, which yielded 10-year cardiovascular risks similar to those associated with prehypertension stages 1 (120/80 mm Hg) and 2 (130/85 mm Hg) and with hypertension stages 1 (140/90 mm Hg) and 2 (160/100 mm Hg). In these analyses, we adjusted for cohort.[21] In our current study, we used the same bootstrap methods,[21] but we stratified our analyses by sex and age to investigate whether outcome-driven thresholds for the self-measured blood pressure might be different in women versus men and in younger versus older subjects. In the derivation of sex- and age-specific thresholds for the HBP from established cutoff limits of the CBP, the key findings can be summarized as follows. First, all of the sex differences in the HBP thresholds, irrespective of the level of the CBP from which they were derived, were small and not statistically significant. On average (Table 3), these thresholds tended to be 0.2 mm Hg systolic and 2.3 mm Hg diastolic lower in women than men. Second, most of the age differences in the HBP thresholds, as derived from the CBP, were nonsignificant except for those corresponding with a CBP of 140 mm Hg systolic (4.3 mm Hg higher in elderly) and

Table 3. Home Blood Pressure Differences According to Sex and Age Yielding 10-Year Risks of a Cardiovascular End Point Equivalent to Given Levels of the Conventional Blood Pressure

Conventional Blood Pressure Level Used as Reference, mm Hg	Sex Difference (Women Minus Men)		Age Difference (Younger Minus Older)	
	Estimate (95% CI)	*P* Value	Estimate (95% CI)	*P* Value
Systolic				
120	3.1 (–5.7 to 11.9)	0.24	–1.9 (–11.9 to 7.8)	0.35
130	1.2 (–2.2 to 4.7)	0.24	–3.1 (–8.3 to 2.0)	0.12
140	–0.6 (–5.8 to 4.5)	0.40	–4.3 (–8.8 to 0.2)	0.03
160	–4.6 (–19.7 to 10.4)	0.27	–6.7 (–19.8 to 6.4)	0.15
Diastolic				
80	–0.2 (–5.3 to 4.8)	0.46	–1.9 (–4.1 to 0.3)	0.04
85	–1.5 (–9.6 to 6.5)	0.35	–1.4 (–7.1 to 4.2)	0.31
90	–3.0 (–13.9 to 7.9)	0.29	–0.9 (–9.0 to 7.3)	0.41
100	–4.3 (–16.8 to 8.2)	0.25	0.0 (–7.5 to 7.5)	0.50

Point estimates used to calculate sex and age-group differences are given in Table 2. Significance levels for the differences between strata were calculated using a large sample z test. CI indicates confidence interval.

Table 4. Conventional Blood Pressure Levels Yielding 10-Year Risks of a Cardiovascular End Point Equivalent to Given Levels of the Home Blood Pressure

Home Blood Pressure Level Used as Reference, mm Hg	Sex				Age			
	Women (n=2843)		Men (n=2175)		<60 y (n=2896)		≥60 y (n=2122)	
	Risk, %	Conventional Blood Pressure, mm Hg	Risk, %	Conventional Blood Pressure, mm Hg	Risk, %	Conventional Blood Pressure, mm Hg	Risk, %	Conventional Blood Pressure, mm Hg
Systolic								
125	3.7	131.9 (125.8–138.1)	9.1	132.6 (129.7–135.5)	2.8	135.4 (129.4–141.4)	14.6	129.3 (122.3–136.4)
130	4.1	140.8 (129.1–152.5)	10.0	139.1 (137.6–140.7)	3.2	143.6 (133.8–153.4)	15.6	136.1 (132.5–139.9)
135	4.5	149.2 (133.5–165.0)	11.0	145.7 (141.7–149.7)	3.6	151.5 (138.9–164.0)	16.8	143.0 (140.5–145.6)
Diastolic								
80	4.1	85.8 (73.1–98.5)	9.9	83.7 (82.6–84.8)	2.9	85.2 (80.6–89.8)	17.4	83.4 (79.2–87.6)
85	4.6	91.7 (76.6–106.8)	11.2	89.9 (85.6–94.1)	3.4	91.0 (84.2–97.8)	19.2	90.3 (82.9–97.6)

Risk refers to the 10-y risk of a cardiovascular end point standardized to the mean distribution of cohort, sex (only for analyses stratified by age), age, body mass index, smoking, cholesterol, previous cardiovascular disease, and diabetes mellitus in the whole study population. In addition, for analyses stratified by age, the risk estimates were standardized to average age within the 2 age groups. Point estimates and 95% confidence intervals were obtained from the bootstrap distribution of 1000 random samples of the study population with replacement (for further details, see Methods). There were no differences in the derived conventional blood pressure thresholds between sexes ($P\geq0.33$) or age ($P\geq0.08$) strata.

80 mm Hg diastolic (1.9 mm Hg higher in elderly). However, there was a consistent trend (Table 3) for the HBP thresholds to be on average 4.0 mm Hg systolic and 1.1 mm Hg diastolic higher in older compared with younger participants.

Methods to derive threshold values for the self-measured blood pressure at home evolved over time.[23] Initially, proposals for reference values for the self-measured blood pressure at home relied mainly on the comparison of the distributions of the HBP between people who were normotensive or had hypertension on CBP measurement.[24,25] The International Database of Home Blood Pressure in Relation to Cardiovascular Outcome consortium recently proposed the first outcome-driven thresholds.[21] Rounded thresholds corresponding to prehypertension stages 1 and 2 and hypertension stages 1 and 2 amounted to 120/75, 125/80, 130/85, and 145/90 mm Hg, respectively.[21] Current guidelines recommend a threshold of 135 mm Hg systolic and 85 mm Hg diastolic as the dividing line between normotension and hypertension based on the self-measured blood pressure at home and propose that these cutoff limits are applicable in both sexes and across the age range. Our current analysis confirms this viewpoint with regard to the application of the proposed thresholds in both sexes. However, outcome-driven thresholds for the HBP might be slightly higher above age 60 years than in younger individuals, but this age difference is probably negligible in clinical practice. Moreover, the relationship between cardiovascular risk and blood pressure is continuous, and thresholds only guide clinicians in diagnosing hypertension and in starting and adjusting antihypertensive drug treatment.

In our current study, we could not fully replicate the results of a previous report based on ambulatory blood pressure measurement.[4] To analyze sex-specific relative and absolute risks associated with blood pressure, we performed CBP and 24-hour ambulatory blood pressure measurements in 9357 subjects (mean age, 52.8 years; 47% women) recruited from 11 populations.[4] As in our current study, women compared with men were at lower risk. The hazard ratios for death and all cardiovascular events were 0.66 and 0.62, respectively ($P<0.001$).[4] However, the relationship of all cardiovascular events with 24-hour systolic blood pressure and the relationships of total mortality and all cardiovascular, cerebrovascular, and cardiac events with nighttime systolic blood pressure were significantly steeper ($P\leq0.045$) in women than in men.[4] Consequently, per a 1-SD decrease, the proportion of potentially preventable events was higher in women than in men for all cardiovascular events (35.9% versus 24.2%) in relation

Table 5. Conventional Blood Pressure Differences According to Sex and Age Yielding 10-Year Risks of a Cardiovascular End Point Equivalent to Given Levels of the Home Blood Pressure

Hone Blood Pressure Level Used as Reference, mm Hg	Sex Difference (Women Minus Men)		Age Difference (Younger Minus Older)	
	Estimate (95% CI)	*P* Value	Estimate (95% CI)	*P* Value
Systolic				
125	–0.7 (–7.4 to 6.1)	0.42	6.1 (–3.1 to 15.3)	0.09
130	1.7 (–10.1 to 13.5)	0.39	7.4 (–3.1 to 17.9)	0.08
135	3.6 (–12.6 to 19.8)	0.33	8.4 (–4.4 to 21.2)	0.09
Diastolic				
80	2.1 (–10.7 to 14.8)	0.37	1.7 (–4.5 to 8.0)	0.29
85	1.9 (–13.8 to 17.5)	0.40	0.7 (–9.3 to 10.8)	0.44

Point estimates used to calculate sex and age-group differences are given in Table 4. Significance levels for the differences between strata were calculated using a large sample z test. CI indicates confidence interval.

to 24-hour systolic blood pressure and for all-cause mortality (23.1% versus 12.3%) and cardiovascular (35.1% versus 19.4%), cerebrovascular (38.3% versus 25.9%), and cardiac (31.0% versus 16.0%) events in relation to systolic nighttime blood pressure.[4] Using the self-measured HBP in our present study, we could not replicate the aforementioned observations.[4] We suspect that the underlying reason is that the ambulatory blood pressure is more informative than the self-measured HBP because 24-hour recordings include the nighttime blood pressure, which was the main drivers of our previous findings[4] and which from a prognostic viewpoint is most accurate.[26,27]

The evidence that the self-measured blood pressure at home is superior to the CBP in risk stratification and in the prediction of cardiovascular complications is overwhelming.[10,23] We, therefore, also derived sex- and age-specific thresholds for the CBP from established cutoff limits of the HBP. The key finding was that the sex and age differences between thresholds for the CBP derived from the HBP were all nonsignificant. However, there was a consistent trend (Table 5) for the conventional systolic thresholds to be on average 7.3 mm Hg higher in younger than they were in older participants. Our current observations highlight the uncertainty about target blood pressure levels to be achieved by drug treatment as summarized in recent US recommendations.[5] This guideline affirmed that there is strong evidence to support treating patients with hypertension aged ≥60 years to a blood pressure goal on conventional measurement of <150/90 mm Hg and patients with hypertension 30 through 59 years of age to a diastolic goal of <90 mm Hg. Furthermore, the guideline stated that there is insufficient evidence in patients with hypertension <60 years for a systolic goal or in those <30 years for a diastolic goal and, therefore, recommended a target blood pressure on conventional measurement of <140/90 mm Hg for those groups based on expert opinion. The threshold of hypertension for the self-measured HBP is 135/85 mm Hg. As shown in Table 4, the corresponding conventional thresholds ranged from 143.0 to 151.5 mm Hg systolic and from 89.8 to 91.7 mm Hg, with no significant differences between strata.

Our current study must be interpreted within the context of its potential limitations. First, the anthropometric characteristics, the time of recruitment, and the number of HBP measurements differed between cohorts. Second, serum cholesterol was unavailable for the Didima cohort and was extrapolated from the ATTICA study. However, the Didima cohort contributed only 10% to the whole study population. Moreover, excluding serum cholesterol from the Cox models did not materially alter our current results. Third, the CBP was the average of only 2 readings obtained at a single examination. Fourth, the participation rate weighted for the contribution of each cohort averaged 57.3%. Finally, our analysis rested on 5 population-based cohorts with an overrepresentation of Asians and whites and might, therefore, not be representative for other ethnic groups, in particular blacks.

Perspectives

From a clinical viewpoint, our current results based on outcome-driven criteria support contemporary guidelines[2,3,6] that propose single blood pressure thresholds that can be indiscriminately applied in both sexes and across the age range. Furthermore, our observations highlight that the evidence underpinning recommendations about the blood pressure levels at which to start antihypertensive drug treatment or target levels to be achieved on treatment remains insufficient. The relationship between cardiovascular complications and blood pressure is linear without threshold above which the risk suddenly increases.[28] In all age groups and in both sexes, the risk increases from levels on conventional measurement as low as 115 mm Hg systolic and 75 mm Hg diastolic.[28] Evidence-based recommendations should meet the clinical needs of most patients but will never be a substitute for clinical judgment. Clinicians must carefully consider and incorporate the clinical characteristics and circumstances of each individual patient in their decision-making process.[5]

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Disclosures

None.

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Novelty and Significance

What Is New?

- This is the first population-based study to derive outcome-driven threshold for the home (HBP) and conventional (CBP) blood pressure stratified by sex and age. We used multivariable-adjusted Cox regression and a bootstrap procedure to determine HBP levels yielding 10-year cardiovascular risks similar to those associated with established systolic/diastolic thresholds on CBP measurement and vice versa.

What Is Relevant?

- The sex differences between HBP thresholds derived from CBP and between CBP thresholds derived from HBP were all nonsignificant.
- The age differences between HBP thresholds derived from CBP and between CBP thresholds derived from HBP were nonsignificant, except for HBP thresholds derived from CBP levels of 140 mm Hg systolic and 80 mm Hg diastolic.

Summary

Our findings based on outcome-driven criteria support contemporary guidelines that propose single blood pressure thresholds that can be indiscriminately applied in both sexes and across the age range.