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Original Article

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Abstract—Mean daytime ambulatory blood pressure (BP) values are considered to be lower than conventional BP values, but data on this relation among younger individuals <50 years are scarce. Conventional and 24-hour ambulatory BP were measured in 9550 individuals not taking antihypertensive treatment from 13 population-based cohorts. We compared individual differences between daytime ambulatory and conventional BP according to 10-year age categories. Age-specific prevalences of white coat and masked hypertension were calculated. Among individuals aged 18 to 30, 30 to 40, and 40 to 50 years, mean daytime BP was significantly higher than the corresponding conventional BP (6.0, 5.2, and 4.7 mm Hg for systolic; 2.5, 2.7, and 1.7 mm Hg for diastolic BP; all $P<0.0001$). In individuals aged 60 to 70 and ≥70 years, conventional BP was significantly higher than daytime ambulatory BP (5.0 and 13.0 mm Hg for systolic; 2.0 and 4.2 mm Hg for diastolic BP; all $P<0.0001$).The prevalence of white coat hypertension exponentially increased from 2.2% to 19.5% from those aged 18 to 30 years to those aged ≥70 years, with little variation between men and women (8.0% versus 6.1%; $P=0.0003$). Masked hypertension was more prevalent among men (21.1% versus 11.4%; $P<0.0001$). The age-specific prevalences of masked hypertension were 18.2%, 27.3%, 27.8%, 20.1%, 13.6%, and 10.2% among men and 9.0%, 9.9%, 12.2%, 11.9%, 14.7%, and 12.1% among women. In conclusion, this large collaborative analysis showed that the relation between daytime ambulatory and conventional BP strongly varies by age. These findings may have implications for diagnosing hypertension and its subtypes in clinical practice. **(*Hypertension*. 2014;64:00-00.)** • **Online Data Supplement**

Key Words: age group ■ ambulatory blood pressure monitoring ■ blood pressure ■ epidemiology ■ hypertension

Elevated blood pressure (BP) is one of the strongest risk factors for morbidity and mortality worldwide.[1] BP-lowering treatment has been shown to be highly effective in preventing hypertension-related cardiovascular events.[2] Accordingly, an accurate diagnosis of hypertension is crucial to target treatment to those individuals at high risk for adverse events.

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Conventional BP monitoring (CBPM) in the doctor's office has been the standard of care for many decades, despite the fact that this technique has many potential limitations. Some of these limitations are minimized through the use of 24-hour ambulatory BP monitoring (ABPM). Accordingly, ABPM has been shown to be a better predictor of cardiovascular complications and death than CBPM[3,4] and may help to implement a more efficient BP-lowering treatment regimen.[5,6]

ABPM values are usually considered to be lower than conventional BP (CBP) values in the same individual. Accordingly, diagnostic thresholds for hypertension based on 24-hour ABPM are lower than those for CBPM.[7] However, most studies to determine the association between ABPM and CBPM have been performed in middle-aged to elderly individuals, and it is relatively unknown whether this relation is similar among younger individuals. Usually, younger individuals are more physically active than older individuals, which may directly affect daytime ambulatory BP (ABP) values. Evidence-based thresholds are important in younger adults, given the long-term implications of diagnosing hypertension in this population group. To address this issue, we performed a large collaborative analysis among 9550 participants not taking BP-lowering drugs and representing a wide age range.

Methods

The International Database on Ambulatory blood pressure in relation to Cardiovascular Outcomes (IDACO) was assembled from random population-based studies with available information on CBPM and ABPM, baseline cardiovascular risk factors, and fatal and nonfatal outcomes during follow-up. Details about study selection and aims of the consortium have been described previously.[8] Currently, the IDACO database contains 12 randomly recruited population cohorts and 12 725 participants. For the purpose of this analysis, we excluded 303 participants aged <18 years, 1389 with missing CBPM, 1878 with incomplete ABPM (<10 valid daytime measurements or <5 valid nighttime measurements),[8] and 1649 participants currently taking antihypertensive treatment, such that 7506 IDACO participants were included in this study.

To increase the number of individuals aged <40 years, data from the population-based Genetic and Phenotypic Determinants of Blood Pressure and Other Cardiovascular Risk Factors (GAPP) study were added to the IDACO data set. GAPP is an ongoing prospective cohort study among all inhabitants of the Principality of Liechtenstein aged 25 to 41 years. The study methodology has been described in detail previously.[9] In brief, between 2010 and 2013, 2170 participants have been enrolled into GAPP. Main exclusion criteria are prevalent cardiovascular disease, a body mass index ≥35 kg/m^2, and current intake of antidiabetic drugs. For the purpose of this study, 2 participants with missing CBPM, 90 participants with incomplete ABPM (<10 valid daytime measurements or <5 valid nighttime measurements; details shown in Table S1 in the online-only Data Supplement), and 34 participants on antihypertensive drug treatment were excluded, leaving 2044 individuals in the GAPP database.

The combined data set for this analysis contained 9550 participants. Written informed consent was obtained from every participant. All responsible local ethics committees approved the corresponding study protocols.

Blood Pressure Monitoring

Details on CBPM and ABPM are provided in the Expanded Methods available in the online-only Data Supplement. In brief, trained observers measured CBPM with validated devices, using the appropriate cuff size, with participants in the sitting position. Observer-measured CBP was the average of 2 consecutive readings obtained either at the persons' home or at an examination center.

ABPM was obtained by validated automated devices programmed to perform measurements every 15 to 30 minutes during daytime and every 30 to 60 minutes during nighttime. Details on time intervals between readings and numbers of programmed and recorded readings in each cohort are provided in Table S1. Daytime and nighttime BP were defined according to short fixed clock–time periods with daytime and nighttime ranging from 10.00 AM to 8.00 PM and from midnight to 6.00 AM in Europeans and South Americans and from 8.00 AM to 6.00 PM and from 10.00 PM to 4.00 AM in Asians.[10] Sensitivity analyses using a diary-based definition of awake and

Table 1. Baseline Characteristics Stratified by Age Categories

	Age Categories, y						
n=9550	18–30	30–40	40–50	50–60	60–70	≥70	*P* Value
No. of participants	1543	2063	2141	1676	1408	719	…
Age, y	26±3.0	35±2.9	43±2.8	54±3.0	63±2.6	74±4.2	…
Sex (male %)	699 (45.3)	955 (46.3)	1040 (48.6)	787 (47.0)	727 (51.6)	422 (58.7)	<0.0001
BMI, kg/m^2	23.3±3.6	24.5±4.0	25.3±4.0	25.8±4.2	25.7±4.2	25.1±4.1	<0.0001
Smoking status (%)							0.002
Former/never	1107 (71.8)	1511 (73.3)	1476 (69.1)	1166 (69.6)	997 (70.9)	542 (75.7)	…
Current	434 (28.2)	550 (26.7)	660 (30.9)	509 (30.4)	410 (29.1)	174 (24.3)	…
Any alcohol intake (%)	720 (46.7)	937 (45.5)	1137 (53.4)	834 (50.6)	753 (54.4)	339 (48.5)	<0.0001
Ethnicity (%)							<0.0001
White	1508 (97.7)	1946 (94.3)	1934 (90.3)	1263 (75.4)	959 (68.1)	491 (68.3)	…
Asians	34 (2.2)	116 (5.6)	207 (9.7)	347 (20.7)	326 (23.2)	120 (16.7)	…
Others	1(0.1)	1 (0.1)	0 (0.0)	66 (3.9)	123 (8.7)	108 (15.0)	…
History of CVD (%)	25 (1.6)	38 (1.8)	35 (1.6)	125 (7.5)	195 (13.9)	144 (20.0)	<0.0001
History of DM (%)	11 (0.7)	20 (1.0)	46 (2.2)	100 (6.0)	138 (9.8)	79 (11.0)	<0.0001
Office hypertension (%)*	112 (7.3)	237 (11.5)	372 (17.4)	498 (29.7)	615 (43.7)	420 (58.4)	<0.0001

Data are mean±SD or number and percentages. BMI indicates body mass index; CVD, cardiovascular disease; and DM, diabetes mellitus.

*Office hypertension was defined as conventional systolic blood pressure ≥140 mm Hg or conventional diastolic blood pressure ≥90 mm Hg.

Table 2. Differences Between Conventional and Ambulatory Daytime Blood Pressures According to Age Categories

Age, y	n	Conventional SBP, mm Hg	Daytime SBP, mm Hg	Conventional DBP, mm Hg	Daytime DBP, mm Hg
18–30	1543	117.0±12.6	123.0±10.9	73.6±9.1	76.1±7.6
30–40	2063	118.6±12.9	123.8±11.3	76.8±9.3	79.5±8.1
40–50	2141	121.5±15.4	126.2±12.7	78.5±10.4	80.2±9.2
50–60	1676	128.6±19.1	129.1±14.1	80.1±11.7	79.8±9.6
60–70	1408	137.3±22.5	132.3±14.7	81.0. ± 11.9	79.0±9.1
≥70	719	148.8±27.9	135.7±15.3	81.6±12.7	77.4±9.7

Data are means±SD. DBP indicates diastolic blood pressure; and SBP, systolic blood pressure.

asleep BP were performed among 7185 participants with this available information.

Normotension was defined as systolic BP <140 mm Hg and diastolic BP <90 mm Hg on CBPM and as daytime systolic BP <135 mm Hg and daytime diastolic BP <85 mm Hg on ABPM. True normotension was defined as normal CBP and normal ABP, white coat hypertension as elevated CBP and normal ABP, masked hypertension as normal CBP and elevated ABP, and sustained hypertension as elevated CBP and elevated ABP.[7]

Other Covariables

Cohort-specific questionnaires were used to obtain information on each participant's medical history, smoking, and alcohol consumption. With regard to alcohol, participants were dichotomized as nondrinkers versus current drinkers of any amount of alcohol. Body mass index was calculated as body weight in kilograms divided by height in meters squared.

Statistical Methods

Baseline characteristics across age deciles were compared using analysis of variance or Kruskal–Wallis tests for continuous variables, as appropriate, and χ^2 tests for categorical variables. Within each age category, we calculated mean CBP and daytime ABP and compared the individual BP indices using paired *t* tests. We assessed whether our findings differed in the subgroup of individuals with hypertension on CBP, who are usually considered for ABPM according to current guidelines.[7] To exclude an important influence of the device technology used, we repeated our main analyses in 3 cohorts, where oscillometric devices for both CBPM and ABPM were available. We also assessed whether our results were similar in those 6 cohorts where CBPM was obtained in the clinic.

We then assessed whether the age-specific differences between mean daytime ABP and CBP were independent of other baseline characteristics using multivariable linear regression analysis. Sex, age, body mass index, smoking, alcohol consumption, history of diabetes mellitus, history of cardiovascular disease, and ethnicity were prespecified covariables for these models. Because BP measurements within an individual study center may be correlated, study center was included as a random effect variable in these models. Separate models were constructed for systolic and diastolic BP. We used analyses stratified by sex to assess for sex-specific differences of our results, and we formally tested for such differences by using multiplicative interaction tests.

Finally, we calculated the prevalence of true normotension, white coat hypertension, masked hypertension, and sustained hypertension as defined by current guidelines separately within each age category.[7] A daytime BP–based definition was used in the main analysis, and a sensitivity analysis was performed using a 24-hour BP of 130/80 mm Hg as a threshold for ambulatory hypertension. We performed another sensitivity analysis where we used awake instead of daytime ABP for the definition of BP categories. Prevalences across categories were compared using χ^2 tests. All analyses were performed using SAS version 9.3 (SAS Institute Inc, Cary, NC). A 2-tailed *P* value <0.05 was considered to indicate statistical significance.

Results

Baseline characteristics of the 9550 participants stratified by age deciles are shown in Table 1. Across categories of increasing age, there was an increasing number of male participants, an increasing prevalence of diabetes mellitus and cardiovascular disease, and a lower prevalence of white individuals. Alcohol consumption, currently smoking cigarettes, and mean body mass index showed a nonlinear distribution across age categories. By design, none of the participants was taking BP-lowering therapy.

Mean systolic and diastolic CBP increased from 117 to 149 mm Hg and from 74 to 82 mm Hg, respectively, from the youngest to the oldest age category, as shown in Table 2. Daytime systolic ABP values also increased with age, although the absolute increase was smaller when compared with CBP. There was a U-shaped relationship between age categories and daytime diastolic ABP (Table 2). Among individuals aged 50 to 60 years, daytime ABP and CBP were similar (*P*=0.20 for

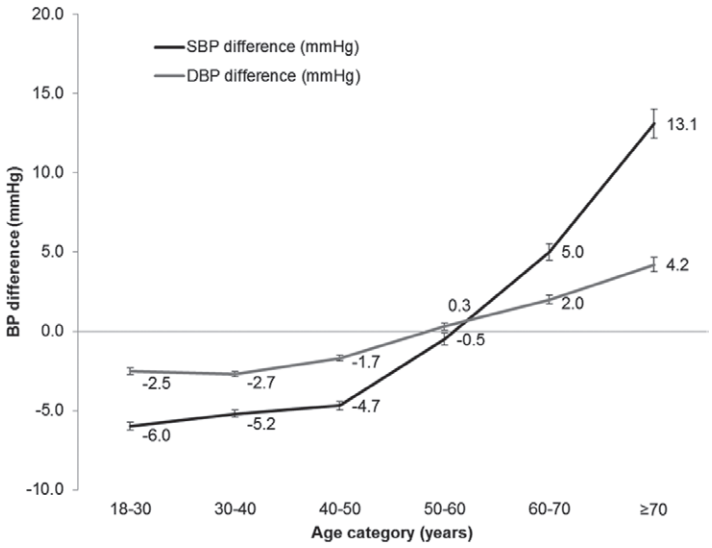

Figure 1. Differences between conventional and ambulatory daytime blood pressure according to age categories. Data are mean blood pressure differences (Daytime – conventional blood pressure). Error bars indicate standard errors of the mean differences. SBP indicates systolic blood pressure; and DBP, diastolic blood pressure.

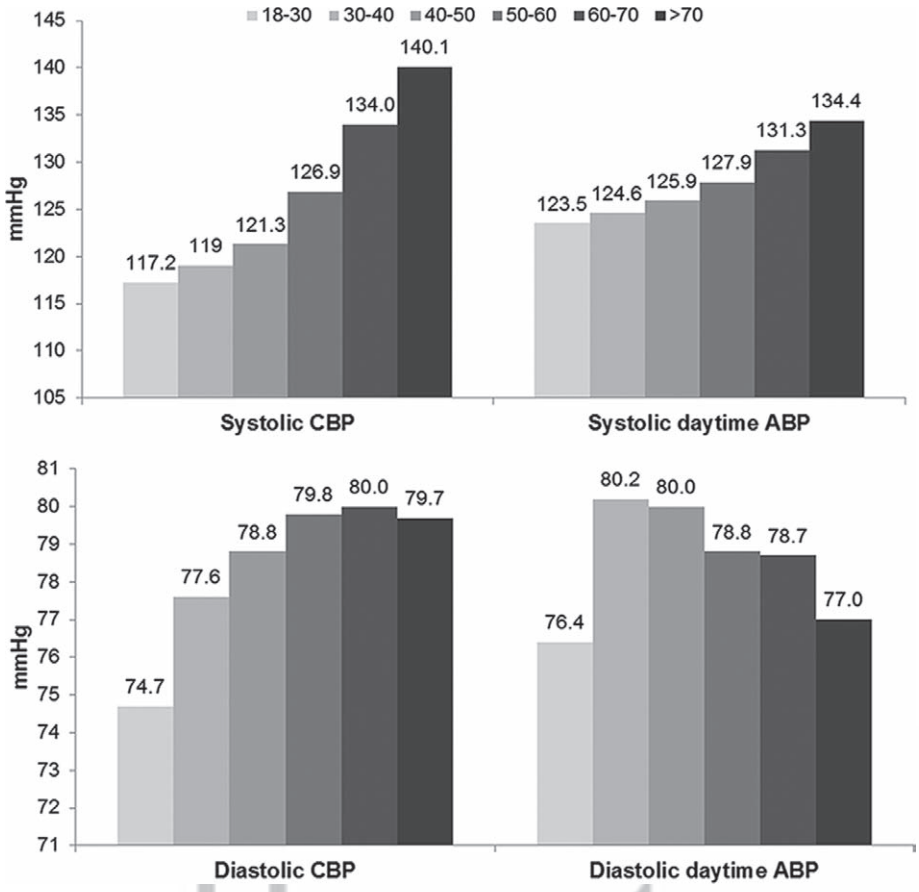

Figure 2. Conventional and ambulatory daytime blood pressure according to age categories. Data are shown by age categories (in years) and represent blood pressure in mm Hg. A diary-based definition of awake blood pressure was used, an information available in 7185 participants. CBP indicates conventional blood pressure; and ABP, ambulatory blood pressure.

the difference in systolic BP and P=0.11 for the difference in diastolic BP). Mean systolic and diastolic daytime ABP were significantly higher than the corresponding CBP among individuals <50 years (all P<0.0001). Among individuals aged ≥60 years, this relationship inversed, such that mean CBP values were significantly higher than daytime ABP values in this group (all P<0.0001). This age-dependent difference between daytime ABP and CBP is summarized in Figure 1. Similar results were obtained when individually defined awake BP was used instead of daytime ABP based on short fixed clock–time periods (Figure 2; Table S2). Among 2254 individuals with hypertension on CBP, daytime ABP was significantly lower in all age groups assessed (P<0.0001), except for systolic BP in those aged 18 to 30 years, as shown in Figure S1. Similar to the main results, the difference between CBP and daytime ABP strongly increased with age. In addition, similar BP relationships across age categories were obtained in the 3 cohorts that used only oscillometric devices (n=3625; Table S3) and in the 6 cohorts where CBP was measured in the clinic (n=7229; Table S4).

In multivariable linear regression analyses, age remained a significant predictor for the difference between daytime ABP and CBP. The β estimates (95% confidence interval) per 1-year increase in age were 0.31 (0.29, 0.33; P<0.0001) for systolic BP and 0.09 (0.08, 0.11; P<0.0001) for diastolic BP.

Although men had higher BP values than women across all BP types and age groups, the age-dependent relationship between daytime ABP and CBP was similar for both men and women, as shown in Table 3 and Figures S2 and S3. Accordingly, multiplicative age by sex interaction tests in the multivariable regression models were not statistically significant for either systolic (P=0.16) or diastolic (P=0.06) BP.

The prevalence of true normotension across increasing age categories was 79.6%, 70.5%, 62.9%, 54.5%, 42.2%, and 30.6% (P<0.0001). The prevalence of sustained hypertension, white coat hypertension, and masked hypertension stratified by age categories is shown in Figure S4. Sustained

Table 3. Conventional and Ambulatory Daytime Blood Pressures According to Age and Sex Categories

Age, y	Sex	n	Conventional SBP, mm Hg	Daytime SBP, mm Hg	Conventional DBP, mm Hg	Daytime DBP, mm Hg
18–30	Women	844	111.6±10.8	118.6±9.3	71.9±8.3	75.2±7.3
	Men	699	123.5±11.5	128.3±10.4	75.7±9.5	77.2±7.8
30–40	Women	1108	113.4±11.3	118.8±9.3	74.1±8.6	77.1±7.4
	Men	955	124.7±12.0	129.5±10.7	80.1±9.1	82.3±8.1
40–50	Women	1101	117.0±14.5	121.5±11.3	75.6±9.8	77.0±8.3
	Men	1040	126.3±14.9	131.0±12.2	81.6±10.2	83.5±9.0
50–60	Women	889	126.6±19.5	126.6±13.7	78.1±11.8	77.5±9.4
	Men	787	130.9±18.5	132.0±13.9	82.4±11.2	82.3±9.2
60–70	Women	681	134.6±21.9	130.9±14.6	79.6±12.1	77.6±8.8
	Men	727	139.8±22.9	133.6±14.7	82.3±11.6	80.4±9.2
≥70	Women	297	145.9±26.2	134.4±15.1	81.0±13.2	76.1±10.0
	Men	422	150.8±29.0	136.7±15.3	82.1±12.4	78.3±9.4

Data are means±SD. DBP indicates diastolic blood pressure; and SBP, systolic blood pressure.

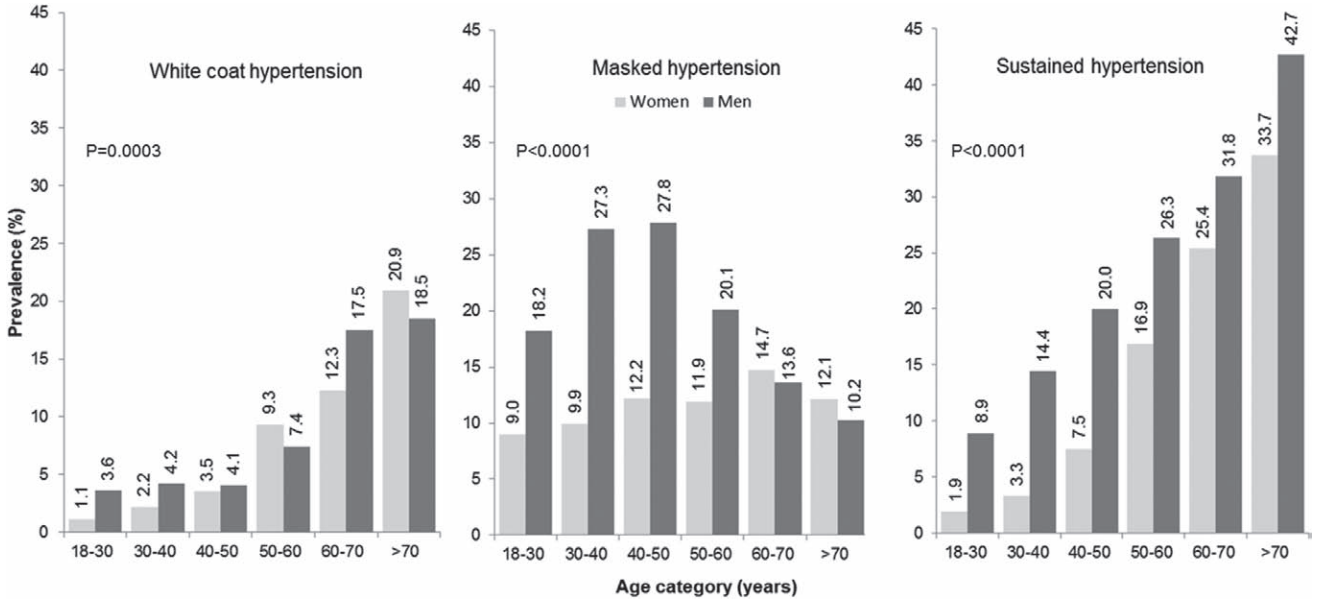

Figure 3. Prevalence of white coat, masked, and sustained hypertension according to age and sex categories. *P* values given are based on a χ^2 test comparing the age-specific prevalences between men and women. White coat hypertension was defined as elevated conventional blood pressure (BP) and normal ambulatory BP, masked hypertension was defined as normal conventional BP and elevated ambulatory BP, sustained hypertension was defined as elevated conventional BP and elevated ambulatory BP. Numbers indicate prevalences.

hypertension exponentially increased across increasing age groups from 5.1% in the youngest age group to 38.9% in those aged ≥70 years (*P*<0.0001). A similar relationship with age was found for white coat hypertension, which was observed in 2.2% of participants aged 18 to 30 years and 19.5% of those aged ≥70 years (*P*<0.0001). In contrast, the prevalence of masked hypertension showed an inverse U-shaped relationship with age. Although masked hypertension was less common in the youngest and oldest age groups (13.2% and 11.0%, respectively), it was more prevalent among those aged 30 to 50 years (18.0% and 19.8%; Figure S4). Similar results were obtained when ambulatory hypertension was defined according to 24-hour instead of daytime BP levels (Figure S5) or when awake BP was used instead of daytime ABP based on short fixed clock–time periods (Figure S6).

The overall prevalence of white coat hypertension was slightly higher in men than in women (8.0% versus 6.1%; *P*=0.0003), but showed a similar relationship with age in both sexes (Figure 3). Masked hypertension was more prevalent in men than in women (21.1% versus 11.4%; *P*<0.0001). In addition, the distribution across age categories markedly differed between men and women (Figure 3). Although in women, the prevalence of masked hypertension gradually increased from 9.0% in the youngest age category to 14.7% among those aged 60 to 70 years, there was an inverse U-shaped association among men, with the highest prevalence among men aged between 30 and 50 years (27.3% and 27.8%, respectively). The prevalence of sustained hypertension was higher in men than in women across all age groups (22.1% versus 11.3%; *P*<0.0001), with a similar distribution across age categories in both sexes (Figure 3).

Discussion

In this large collaborative study of 13 population-based cohorts, we found that the difference between daytime ABP and CBP markedly differs according to age. Although CBP was significantly higher than daytime ABP among those aged ≥60 years, as has been described in many earlier studies, this association was inverse among individuals <50 years. Our results were robust to sensitivity analyses where different definitions of ambulatory hypertension were used. The inverse relationship in younger individuals has received little attention previously,[11–13] and most available studies mainly focused on the direct relationship between age and the white coat response.[14,15] As in our work, these studies found that the white coat response increases with increasing age and that it was stronger among individuals with office hypertension. Some earlier studies found a higher prevalence of white coat hypertension among women.[16] The differential findings in our study may be explained by the high number of younger individuals assessed (Figure 3).

CBPM is usually performed in a relatively standardized setting in the physician's office, whereas daytime ABPM is obtained in the unstandardized individual real-life environment. As physical activity declines with increasing age,[17] less exercise and a more sedentary behavior during ABPM may be one reason why daytime ABP is relatively higher than CBP in younger compared with older individuals. Furthermore, the observed age-dependent differences may also be partly explained by the fact that many individuals aged <60 years are part of the active workforce and many of the individuals aged ≥60 years are retired. This hypothesis is in agreement with our finding that the prevalence of masked hypertension was much higher among men <50 years, as they more often have a physically demanding profession when compared with their female counterparts.

However, if these hypotheses are true, then the prognostic relevance of masked hypertension in younger individuals is unclear, given that an increased physical activity has a

favorable effect on various health outcomes.[18] Several studies mostly among elderly individuals have shown that the outcome among individuals with masked hypertension is similar to those with sustained hypertension,[19,20] which is in agreement with the finding that ABP is a better predictor of cardiovascular events than CBP and that the prognostic information is partly independent of CBP.[3,4] Whether these strong associations between masked hypertension and cardiovascular events are transferable to younger, mainly male individuals, needs to be defined in prospective studies.

Taken together, we think that these findings may have important implications for the diagnosis of hypertension. Our study suggests that age-specific cut-offs for daytime ABP may be considered. Prospective studies are needed to define these cut-offs. If these studies show that the prognostic effect of masked hypertension is independent of age, then ABPM should be used more often in middle-aged men. The use of ABPM in individuals with nonhypertensive CBP is supported by recent findings showing that ABP also improves risk stratification in normotensive and prehypertensive individuals.[21] Our data also show that, among individuals with office hypertension, a white coat effect is present in all age groups, although much higher among older individuals, such that algorithms looking for white coat hypertension proposed by current guidelines seem to be applicable independent of age.[7]

Strengths of the current analysis include the large sample size, the large number of young adults available for the study, and the population-based design of all cohorts included. Potential limitations that need to be taken into account in the interpretation of this study include the following. First, assessments of anthropometric characteristics differed across cohorts. Second, CBPM and ABPM were not standardized with regard to device used and intervals set between measurements. However, all daytime and nighttime periods in all IDACO cohorts were calculated in a homogenous fashion, as described previously.[22] Third, the number of nonwhite individuals was small and heterogeneous, such that we cannot exclude a differential relationship between daytime ABP and CBP in some other populations. Finally, this was a cross-sectional study, and the prognostic significance of our findings needs to be evaluated in future studies.

Perspectives

In this large collaborative study of 9550 individuals across a wide age range, we describe important age-dependent differences in the relationship between CBP and daytime ABP. In individuals aged <50 years, daytime ABP was significantly higher than CBP, whereas the inverse was found in those aged ≥60 years. These findings may have important implications for the diagnosis of hypertension and its subtypes, although the prognostic significance of our results needs to be defined in future studies.

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Disclosures

None.

References

1. Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380:2224–2260.
2. Turnbull F; Blood Pressure Lowering Treatment Trialists' Collaboration. Effects of different blood-pressure-lowering regimens on major cardiovascular events: results of prospectively-designed overviews of randomised trials. *Lancet*. 2003;362:1527–1535.
3. Conen D, Bamberg F. Noninvasive 24-h ambulatory blood pressure and cardiovascular disease: a systematic review and meta-analysis. *J Hypertens*. 2008;26:1290–1299.
4. Staessen JA, Thijs L, Fagard R, O'Brien ET, Clement D, de Leeuw PW, Mancia G, Nachev C, Palatini P, Parati G, Tuomilehto J, Webster J. Predicting cardiovascular risk using conventional vs ambulatory blood pressure in older patients with systolic hypertension. Systolic Hypertension in Europe Trial Investigators. *JAMA*. 1999;282:539–546.
5. Staessen JA, Byttebier G, Buntinx F, Celis H, O'Brien ET, Fagard R. Antihypertensive treatment based on conventional or ambulatory blood pressure measurement. A randomized controlled trial. Ambulatory Blood Pressure Monitoring and Treatment of Hypertension Investigators. *JAMA*. 1997;278:1065–1072.
6. Conen D, Tschudi P, Martina B. Twenty-four hour ambulatory blood pressure for the management of antihypertensive treatment: a randomized controlled trial. *J Hum Hypertens*. 2009;23:122–129.
7. Mancia G, Fagard R, Narkiewicz K, et al. 2013 ESH/ESC guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). *Eur Heart J*. 2013;34:2159–2219.
8. Thijs L, Hansen TW, Kikuya M, et al; IDACO Investigators. The International Database of Ambulatory Blood Pressure in relation to Cardiovascular Outcome (IDACO): protocol and research perspectives. *Blood Press Monit*. 2007;12:255–262.
9. Conen D, Schön T, Aeschbacher S, Paré G, Frehner W, Risch M, Risch L. Genetic and phenotypic determinants of blood pressure and other cardiovascular risk factors (GAPP). *Swiss Med Wkly*. 2013;143:w13728.
10. Boggia J, Li Y, Thijs L, et al; International Database on Ambulatory blood pressure monitoring in relation to Cardiovascular Outcomes (IDACO) investigators. Prognostic accuracy of day versus night ambulatory blood pressure: a cohort study. *Lancet*. 2007;370:1219–1229.
11. O'Brien E, Murphy J, Tyndall A, Atkins N, Mee F, McCarthy G, Staessen J, Cox J, O'Malley K. Twenty-four-hour ambulatory blood pressure in

men and women aged 17 to 80 years: the Allied Irish Bank Study. *J Hypertens*. 1991;9:355–360.
12. Rasmussen SL, Torp-Pedersen C, Borch-Johnsen K, Ibsen H. Normal values for ambulatory blood pressure and differences between casual blood pressure and ambulatory blood pressure: results from a Danish population survey. *J Hypertens*. 1998;16:1415–1424.
13. Ishikawa J, Ishikawa Y, Edmondson D, Pickering TG, Schwartz JE. Age and the difference between awake ambulatory blood pressure and office blood pressure: a meta-analysis. *Blood Press Monit*. 2011;16:159–167.
14. Staessen JA, O'Brien ET, Amery AK, Atkins N, Baumgart P, De Cort P, Degaute JP, Dolenc P, De Gaudemaris R, Enström I. Ambulatory blood pressure in normotensive and hypertensive subjects: results from an international database. *J Hypertens Suppl*. 1994;12:S1–12.
15. Verdecchia P, Schillaci G, Borgioni C, Ciucci A, Porcellati C. Prognostic significance of the white coat effect. *Hypertension*. 1997;29:1218–1224.
16. Verdecchia P, Reboldi GP, Angeli F, Schillaci G, Schwartz JE, Pickering TG, Imai Y, Ohkubo T, Kario K. Short- and long-term incidence of stroke in white-coat hypertension. *Hypertension*. 2005;45:203–208.
17. Shaw BA, Liang J, Krause N, Gallant M, McGeever K. Age differences and social stratification in the long-term trajectories of leisure-time physical activity. *J Gerontol B Psychol Sci Soc Sci*. 2010;65:756–766.
18. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT; Lancet Physical Activity Series Working Group. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*. 2012;380:219–229.
19. Björklund K, Lind L, Zethelius B, Andrén B, Lithell H. Isolated ambulatory hypertension predicts cardiovascular morbidity in elderly men. *Circulation*. 2003;107:1297–1302.
20. Bobrie G, Clerson P, Ménard J, Postel-Vinay N, Chatellier G, Plouin PF. Masked hypertension: a systematic review. *J Hypertens*. 2008;26:1715–1725.
21. Brguljan-Hitij J, Thijs L, Li Y, et al; International Database on Ambulatory Blood Pressure in Relation to Cardiovascular Outcome Investigators. Risk stratification by ambulatory blood pressure monitoring across JNC classes of conventional blood pressure. *Am J Hypertens*. 2014;27:956–965.
22. Kikuya M, Hansen TW, Thijs L, Björklund-Bodegård K, Kuznetsova T, Ohkubo T, Richart T, Torp-Pedersen C, Lind L, Ibsen H, Imai Y, Staessen JA; International Database on Ambulatory blood pressure monitoring in relation to Cardiovascular Outcomes Investigators. Diagnostic thresholds for ambulatory blood pressure monitoring based on 10-year cardiovascular risk. *Circulation*. 2007;115:2145–2152.

Novelty and Significance

What Is New?

- This is the first large study to compare individual conventional and daytime ambulatory blood pressure (BP) values across a wide age range.

What Is Relevant?

- Among individuals aged <50 years, mean daytime ambulatory BP was significantly higher than conventional BP.
- Among individuals aged ≥60 years, conventional BP was significantly higher than mean daytime ambulatory BP.
- The prevalence of white coat and masked hypertension strongly varied by age. White coat hypertension exponentially increased with age, with little variation between men and women. Masked hypertension was more prevalent among men (21.1% versus 11.4%; $P<0.0001$), with the highest prevalence among men aged 30 to 50 years.

Summary

We found important age-dependent differences in the relationship between conventional daytime ambulatory BP. These findings may have important implications for the diagnosis of hypertension and its subtypes.

Age-specific differences between conventional and ambulatory daytime blood pressure values

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Short title: Differences in CBP versus ambulatory daytime BP

Supplemental Material

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Expanded methods

Blood pressure measurement

Conventional blood pressure was measured by trained observers with a mercury sphygmomanometer, [1-7] with validated auscultatory [8] (USM-700F, UEDA Electronic Works, Tokyo, Japan) or oscillometric [9, 10] (OMRON HEM-705CP, Omron Corporation, Tokyo, Japan; Microlife BP3AG1, Switzerland) devices, using the appropriate cuff size, with participants in the sitting position. For the present study, only sitting blood pressure values were used. Conventional blood pressure was the average of two consecutive readings obtained either at the person's home [1-4, 9] or at an examination center. [5-8, 10]

We programmed portable monitors to obtain ambulatory blood pressure readings at 30 minute intervals throughout the whole day, [8] or at intervals ranging from 15 [1, 2, 5, 10] to 30 [8] minutes during daytime and from 20 [6] to 45 [3] minutes at night. Detailed information on the time intervals between readings, numbers of programmed and recorded readings in each cohort are shown in Table S1. The devices implemented an auscultatory algorithm (Accutracker II) in Uppsala, [6] an oscillometric technique (SpaceLabs 90202 and 90207, Nippon Colin, and ABPM 630), [1-5, 7, 8] or a combination of the two (Schiller BR-102 plus). [10] According to predefined criteria,[11] recordings with <10 daytime readings or <5 nighttime readings were excluded from the analyses.

In seven cohorts (Ohasama, Uppsala, JingNing, Pilsen, Dublin, Padua, Liechtenstein), ambulatory blood pressure and conventional blood pressure monitoring were performed on the same day in virtually all subjects. In Noorderkempen ambulatory blood pressure and conventional blood pressure monitoring were performed within 2 weeks in all but 6 subjects. In Maracaibo ambulatory blood pressure and conventional blood pressure monitoring were performed within 2 weeks in >92% of the subjects In Krakow ambulatory blood pressure and conventional blood pressure monitoring were performed within 2 days in all but 2 subjects. In Novosibirsk, Montevideo and Copenhagen ambulatory blood pressure and conventional blood pressure monitoring were performed within 2 weeks in 71%, 94% and 80% of the subjects respectively.

References

1. Kuznetsova T, Malyutina S, Pello E, Thijs L, Nikitin Y, Staessen JA. Ambulatory blood pressure of adults in novosibirsk, russia: Interim report on a population study. *Blood Press Monit*. 2000;5:291-296.
2. Kuznetsova T, Staessen JA, Kawecka-Jaszcz K, Babeanu S, Casiglia E, Filipovsky J, Nachev C, Nikitin Y, Peleska J, O'Brien E. Quality control of the blood pressure phenotype in the european project on genes in hypertension. *Blood Press Monit*. 2002;7:215-224.
3. Li Y, Wang JG, Gao P, Guo H, Nawrot T, Wang G, Qian Y, Staessen JA, Zhu D. Are published characteristics of the ambulatory blood pressure generalizable to rural chinese? The jingning population study. *Blood Press Monit*. 2005;10:125-134.
4. Staessen JA, Bieniaszewski L, O'Brien ET, Imai Y, Fagard R. An epidemiological approach to ambulatory blood pressure monitoring:The belgian population study. *Blood Press Monit*. 1996;1:13-26.
5. Hansen TW, Jeppesen J, Rasmussen S, Ibsen H, Torp-Pedersen C. Ambulatory blood pressure monitoring and risk of cardiovascular disease: A population based study. *Am J Hypertens*. 2006;19:243-250.
6. Ingelsson E, Bjorklund-Bodegard K, Lind L, Arnlov J, Sundstrom J. Diurnal blood pressure pattern and risk of congestive heart failure. *JAMA*. 2006;295:2859-2866.
7. O'Brien E, Murphy J, Tyndall A, Atkins N, Mee F, McCarthy G, Staessen J, Cox J, O'Malley K. Twenty-four-hour ambulatory blood pressure in men and women aged 17 to 80 years: The allied irish bank study. *J Hypertens*. 1991;9:355-360.
8. Ohkubo T, Hozawa A, Yamaguchi J, Kikuya M, Ohmori K, Michimata M, Matsubara M, Hashimoto J, Hoshi H, Araki T, Tsuji I, Satoh H, Hisamichi S, Imai Y. Prognostic significance of the nocturnal decline in blood pressure in individuals with and without high 24-h blood pressure: The ohasama study. *J Hypertens*. 2002;20:2183-2189.
9. Schettini C, Bianchi M, Nieto F, Sandoya E, Senra H. Ambulatory blood pressure: Normality and comparison with other measurements. Hypertension working group. *Hypertension*. 1999;34:818-825.
10. Conen D, Schon T, Aeschbacher S, Pare G, Frehner W, Risch M, Risch L. Genetic and phenotypic determinants of blood pressure and other cardiovascular risk factors (gapp). *Swiss Med Wkly*. 2013;143:w13728.
11. Thijs L, Hansen TW, Kikuya M, et al. The international database of ambulatory blood pressure in relation to cardiovascular outcome (idaco): Protocol and research perspectives. *Blood Press Monit*. 2007;12:255-262.

Table S1: Number of 24 hour ambulatory blood pressure readings in IDACO cohorts and GAPP

IDACO Cohorts N=9550	N of Subjects	Interval between Readings (minutes)		N of programmed Readings	N of Recorded Readings				
		Daytime	Nighttime		Median	P5	P25	P75	P95
Copenhagen County, Denmark	1823	15	30	80	80	67	78	81	83
Ohasama, Iwate prefecture, Japan	851	30	30	48	46	36	42	48	50
Noorderkempen, Belgium	1175	20	40	55	53	38	41	56	58
Montevideo, Uruguay	1188	20	40	60	38	30	35	40	43
JingNing, Zhejiang, China	299	20	45	65	56	52	55	56	57
Octyabrsky District, Novosibirsk, Russia	204	15	30	76	72	57	65	76	78
Pilsen, Czech Republic	133	15	30	76	76	54	71	80	82
Dublin, Ireland	930	30	30	48	46	38	44	48	49
Padua, Italy	266	15	30	76	77	65	74	78	84
Niepolomice, Kraków, Poland	244	15	30	76	75	63	72	77	79
Maracaibo, Venezuela	393	15	30	81	67	50	61	71	78
Schaan, Liechtenstein	2044	15	30	76	75	63	72	76	77

N = number; IDACO= International Database on Ambulatory blood pressure in relation to Cardiovascular Outcomes; GAPP= genetic and phenotypic determinants of blood pressure and other cardiovascular risk factors.

Table S2 Differences between conventional and ambulatory daytime blood pressures according age categories

Age (years)	N	Conventional SBP (mmHg)	Daytime SBP (mmHg)	SBP difference (mmHg)	Conventional DBP (mmHg)	Daytime DBP (mmHg)	DBP difference (mmHg)
18-30	1035	117.2 ± 12.7	123.5 ± 11.8	-6.3 ± 9.8	74.7 ± 8.9	76.4 ± 8.1	-1.7 ± 7.8
30-40	1612	119.0 ± 13.1	124.6 ± 11.9	-5.6 ± 10.1	77.6 ± 9.3	80.2 ± 8.6	-2.6 ± 7.5
40-50	1710	121.3 ± 15.2	125.9 ± 12.4	-4.6 ± 11.9	78.8 ± 10.4	80.0 ± 9.4	-1.2 ± 8.5
50-60	1301	126.9 ± 17.4	127.9 ± 13.2	-1.0 ± 14.0	79.8 ± 11.4	78.8 ± 9.1	1.0 ± 9.0
60-70	1002	134.0 ± 19.6	131.3 ± 14.2	2.7 ± 15.8	80.0 ± 11.7	78.7 ± 8.9	1.3 ± 9.3
≥70	525	140.1 ± 18.2	134.4 ± 14.2	5.7 ± 15.5	79.7 ± 10.7	77.0 ± 8.8	2.7 ± 9.6

N=7185. Daytime ambulatory blood pressure was defined individually according to diary based information. Participants with missing information on awake BP were excluded. Data are means ± standard deviation.

SBP = systolic blood pressure, DBP = diastolic blood pressure

Table S3 Differences between conventional and ambulatory daytime blood pressures according age categories

Age	N	Conventional SBP	Daytime SBP	SBP difference	Conventional DBP	Daytime DBP	DBP difference
18-30	608	117.3 ± 12.7	123.6 ± 12.1	-6.3 ± 9.5	75.7 ± 8.5	76.4 ± 10.0	-0.7 ± 7.3
30-40	1294	118.9 ± 12.7	124.8 ± 11.9	-5.9 ± 9.4	77.8 ± 8.9	78.8 ± 10.9	-1.0 ± 7.0
40-50	831	121.1 ± 15.5	125.8 ± 13.2	-4.7 ± 10.4	79.2 ± 10.2	80.9 ± 10.6	-1.7 ± 7.9
50-60	288	136.9 ± 25.2	127.3 ± 15.3	9.6 ± 18.6	83.2 ± 12.6	81.4 ± 10.4	1.8 ± 10.2
60-70	353	148.9 ± 28.5	128.9 ± 15.4	20.0 ± 22.3	82.7 ± 12.5	78.7 ± 9.6	4.0 ± 10.7
≥70	251	166.7 ± 34.1	135.2 ± 16.4	31.5 ± 29.4	85.7 ± 15.3	77.6 ± 11.1	8.1 ± 14.6

N=3625. Only cohorts with available data on oscillometric recordings for both conventional and ambulatory blood pressure monitoring were considered (Montevideo, Uruguay; Maracaibo, Venezuela; Schaan, Liechtenstein)

SBP = systolic blood pressure, DBP = diastolic blood pressure

Table S4 Differences between conventional and ambulatory daytime blood pressures according age categories

Age	N	Conventional SBP	Daytime SBP	SBP difference	Conventional DBP	Daytime DBP	DBP difference
18-30	927	116.5 ± 12.8	123.2 ± 11.4	-6.7 ± 9.8	74.2 ± 8.9	76.9 ± 7.9	-2.7 ± 7.6
30-40	1593	118.5 ± 12.7	124.2 ± 11.6	-5.7 ± 9.6	77.2 ± 8.9	80.0 ± 8.2	-2.8 ± 7.1
40-50	1632	120.8 ± 15.2	127.0 ± 12.9	-6.2 ± 12.0	78.5 ± 10.5	80.6 ± 9.5	-2.1 ± 8.1
50-60	1217	128.5 ± 20.0	129.9 ± 14.4	-1.4 ± 16.7	80.2 ± 12.2	79.7 ± 10.0	0.5 ± 9.8
60-70	1221	137.7 ± 22.9	132.8 ± 14.6	4.9 ± 20.6	81.3. ± 12.2	79.1 ± 9.2	2.2 ± 10.1
≥70	639	149.9 ± 28.6	136.5 ± 15.3	13.4 ± 26.1	82.4 ± 13.0	77.6 ± 9.9	4.8 ± 11.9

N=7229. Only cohorts with where conventional BP was measured in the clinic were considered (Dublin, Ireland; Montevideo, Uruguay; Maracaibo, Venezuela; Ohasama, Japan; Copenhagen, Denmark; Schaan, Liechtenstein)

SBP = systolic blood pressure, DBP = diastolic blood pressure

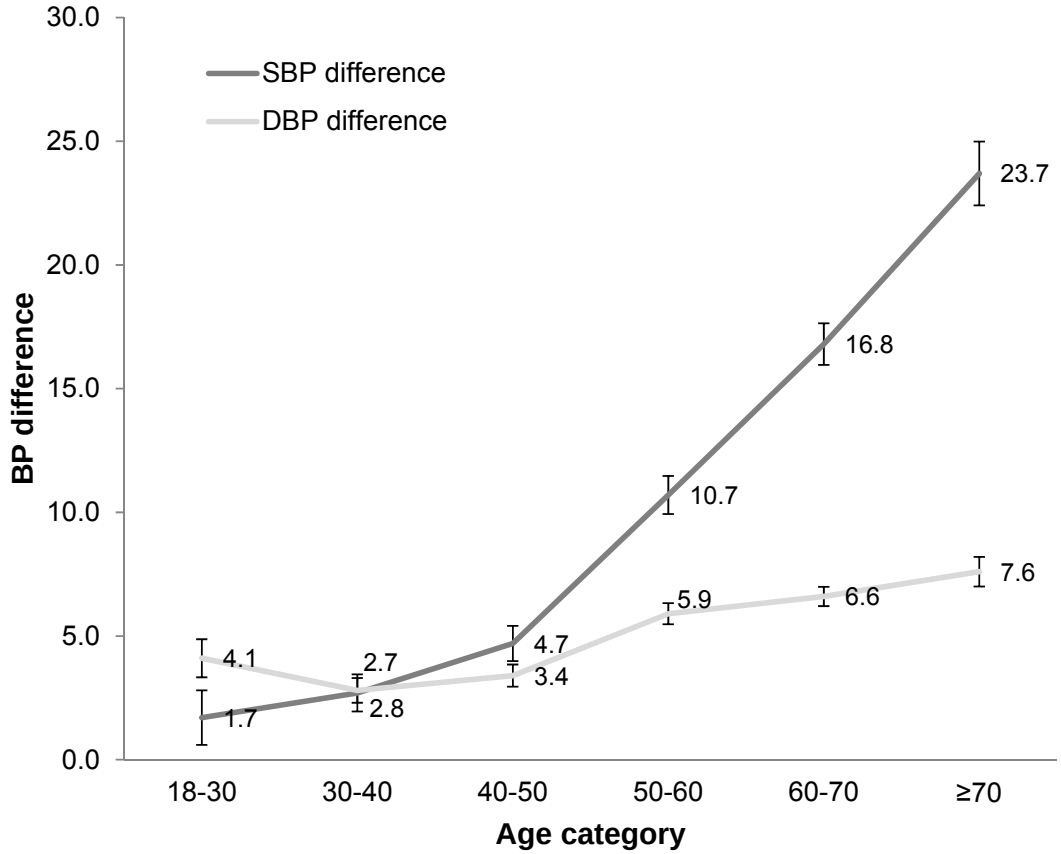

Figure S1 Differences between conventional and ambulatory daytime blood pressures according to age categories in 2254 individuals with office hypertension

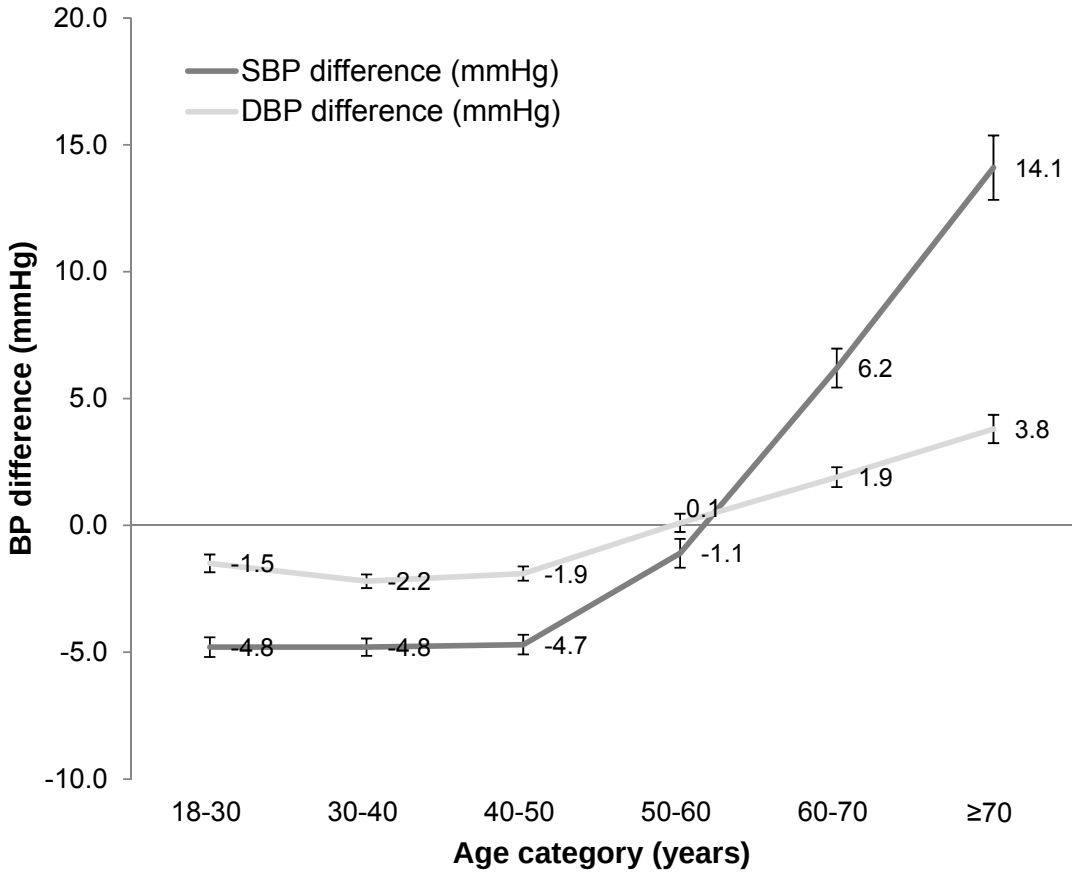

Figure S2 Differences between conventional and ambulatory daytime blood pressures according to age categories among men

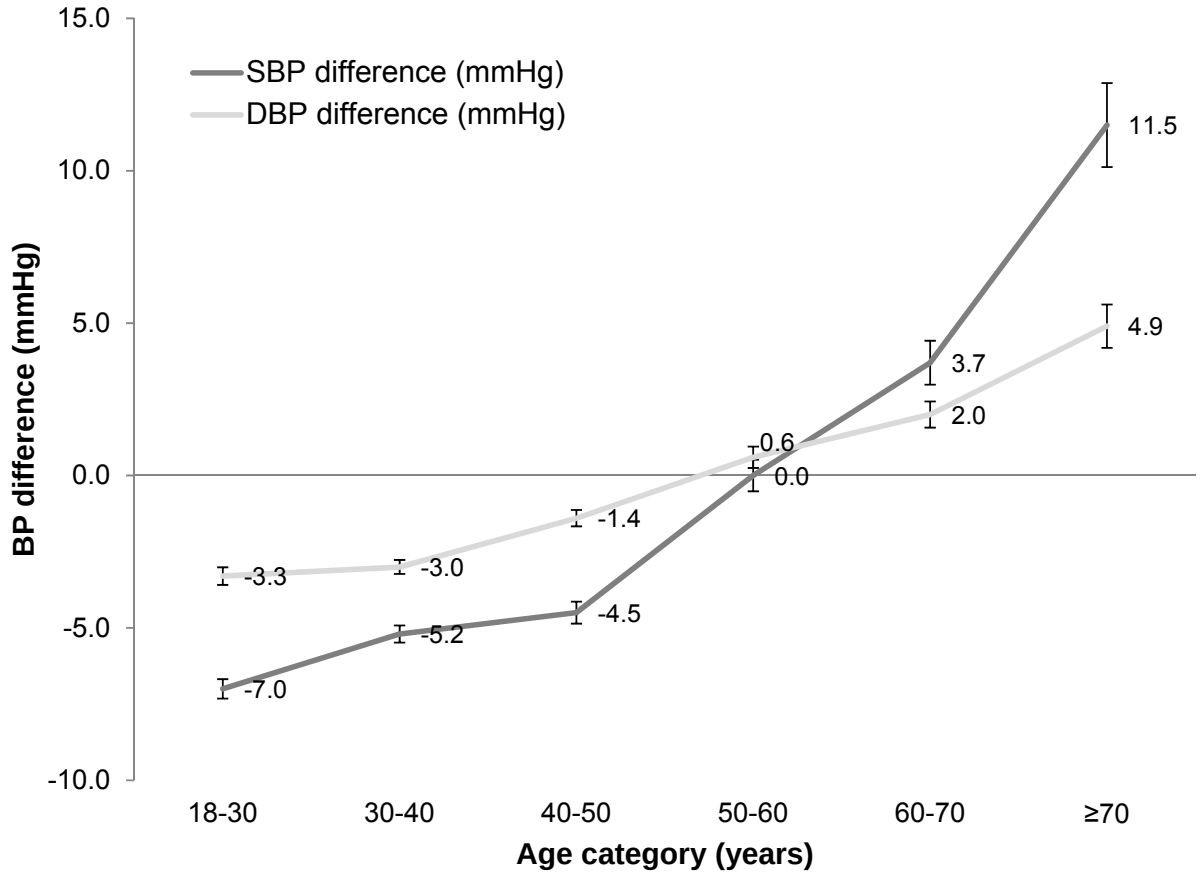

Figure S3 Differences between conventional and ambulatory daytime blood pressures according to age categories among women

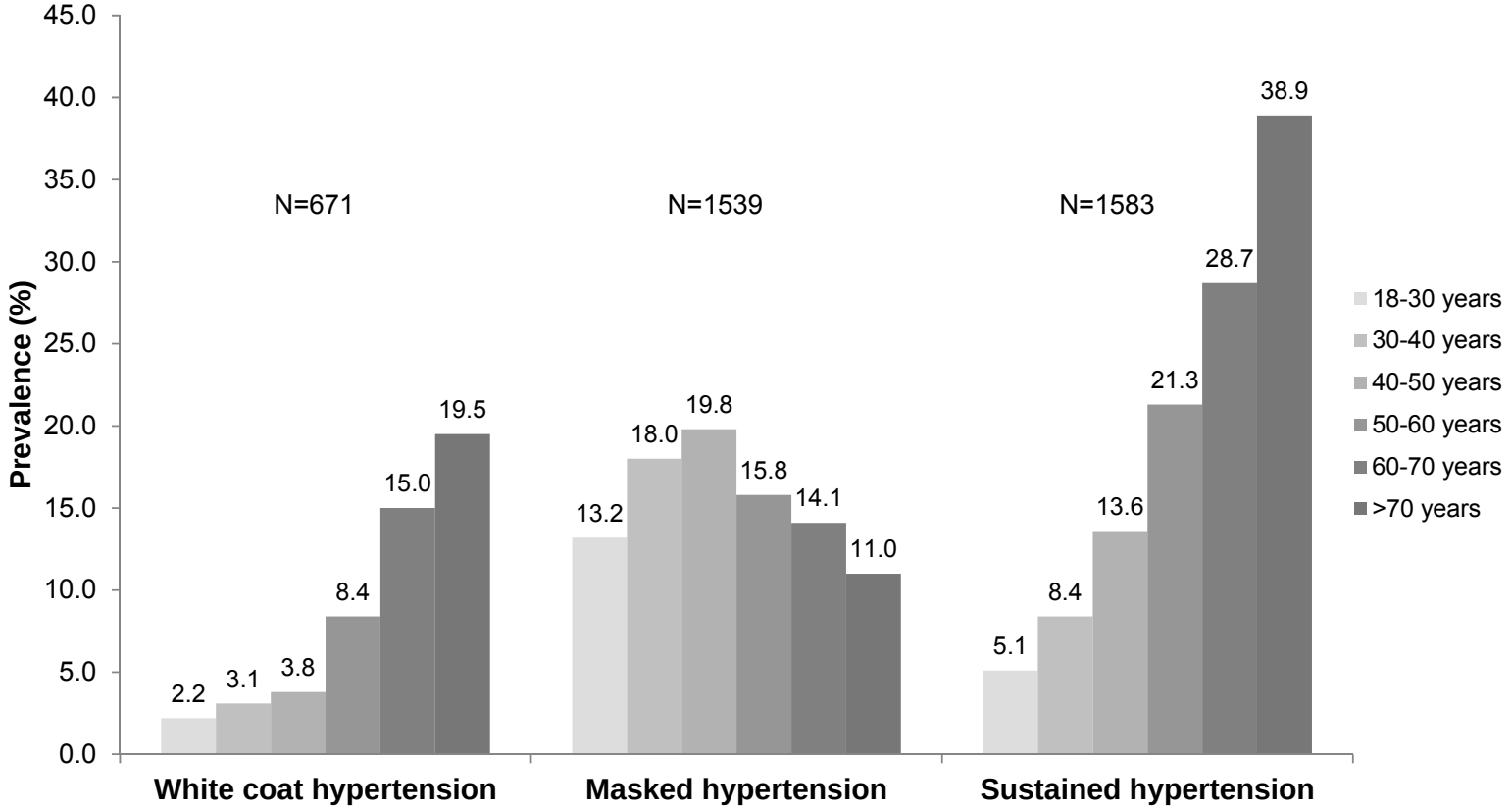

Figure S4 Prevalence of white coat, masked and sustained hypertension according to age categories

n= 9550. Daytime ambulatory blood pressure was defined according to short fixed clock-time periods.
White coat hypertension was defined as elevated conventional BP and normal ambulatory BP, masked hypertension was defined as normal conventional BP and elevated ambulatory BP, sustained hypertension was defined as elevated conventional BP and elevated ambulatory BP. Numbers indicate prevalences.

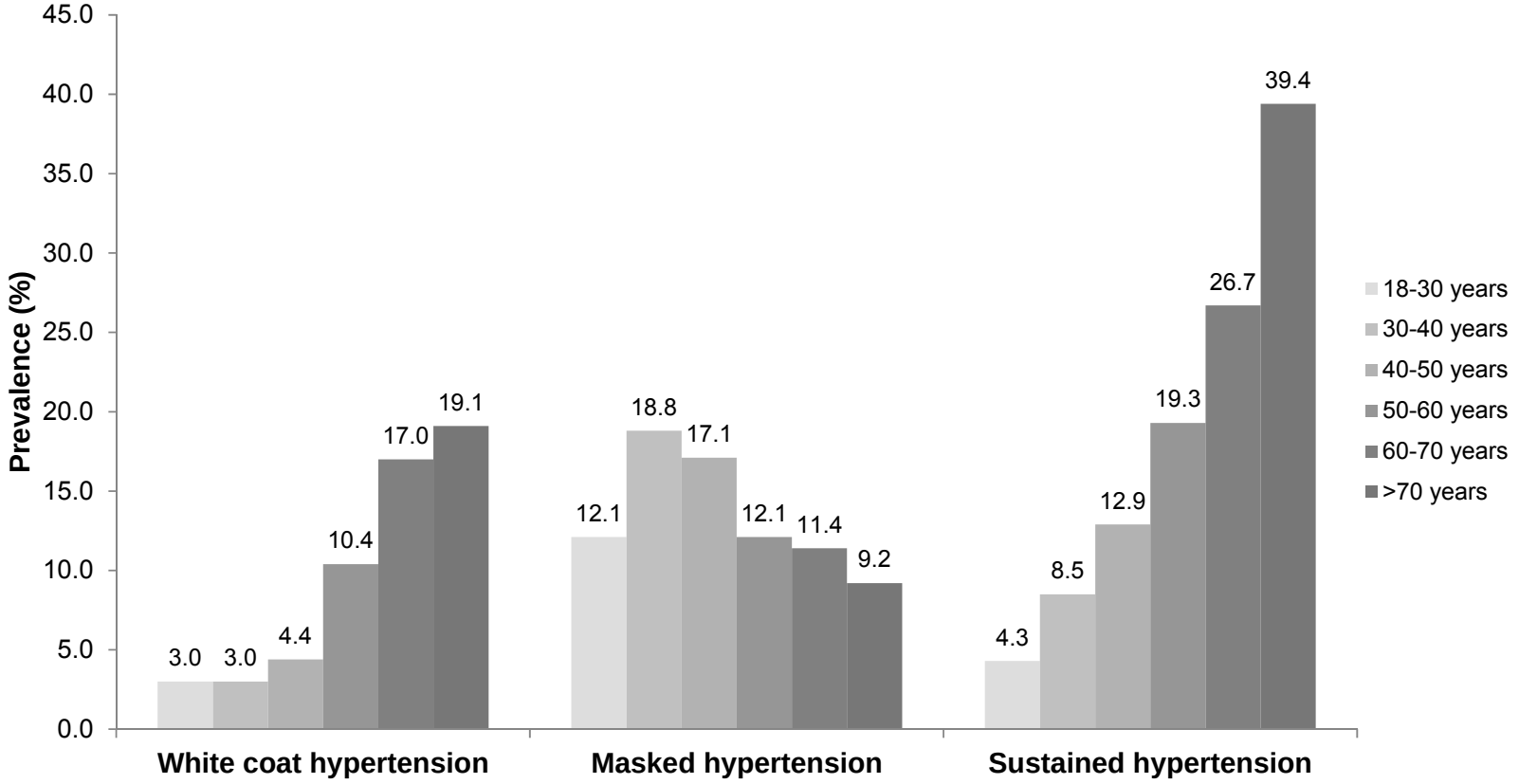

Figure S5 Prevalence of white coat, masked and sustained hypertension according to age categories

n= 9550. Ambulatory hypertension was defined as 24h blood pressure ≥130 for systolic or ≥80mmHg for diastolic blood pressure. White coat hypertension was defined as elevated conventional BP and normal ambulatory BP, masked hypertension was defined as normal conventional BP and elevated ambulatory BP, sustained hypertension was defined as elevated conventional BP and elevated ambulatory BP.

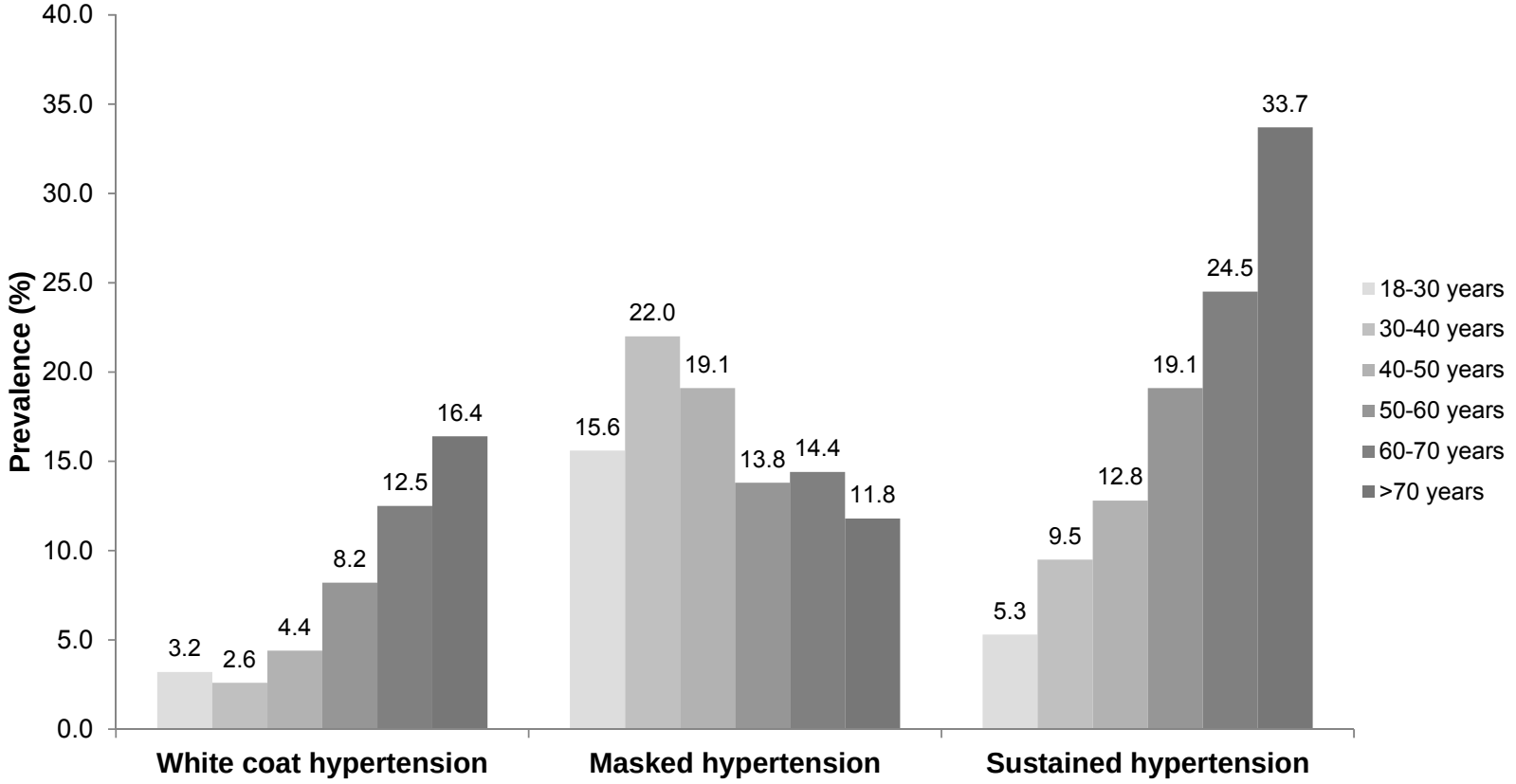

Figure S6 Prevalence of white coat, masked and sustained hypertension according to age categories

N= 7185. Daytime ambulatory blood pressure was defined individually according to diary based information. Participants with missing information on awake BP were excluded.
White coat hypertension was defined as elevated conventional BP and normal ambulatory BP, masked hypertension was defined as normal conventional BP and elevated ambulatory BP, sustained hypertension was defined as elevated conventional BP and elevated ambulatory BP