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Age and the Difference between Awake Ambulatory Blood Pressure and Office Blood Pressure: a Meta-analysis

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Abstract

Background—Ambulatory blood pressure (ABP) is a better predictor of adverse cardiovascular events than office BP (OBP). Due to the extensive literature on the "white coat effect", it is widely believed that ABP tends to be lower than OBP, with statements to this effect in JNC VII. However, recent evidence suggests that the difference varies systematically with age.

Methods—We searched PubMed to identify population studies, published before April 2009, which assessed office BP and either ABP or home BP. Because of significant heterogeneity in the outcomes, random effects models were used for the meta-analyses.

Results—OBP increased with age more steeply than awake ABP. OBP became higher than awake systolic/diastolic ABP at the age of 51.3/42.7 years in men (13 studies, N=3562) and 51.9/42.3 years in women (11 studies, N=2585). In the data in which OBP and HBP were measured (8 studies, N=4916), OBP was higher than HBP at all ages. In the data in which OBP, awake ABP and HBP were all measured (2 studies, N=895), awake ABP was higher than HBP at younger ages, becoming similar at the older age.

Conclusion—OBP tends to be higher than awake ABP only after age 50 for systolic and age 45 for diastolic, but is lower than ABP at younger ages; in contrast OBP tends to exceed HBP at all ages.

Keywords

Awake blood pressure; home blood pressure; office blood pressure; meta-analysis

Introduction

The incidence of cardiovascular events increases with the level of blood pressure (BP)[1]. Historically, BP has been measured manually by physicians or nurses using mercury sphygmomanometers. Recently, automatic BP devices that use the oscillometric method to take readings have become available and are increasingly being employed in clinical practice to measure "out-of-office" BP. One such device is the twenty-four hour ambulatory BP (ABP) monitor, by which BP readings are taken every 15–30 minutes over the course of 24 hours during all physical activities and sleep. However, awake ABP and office BP (OBP)

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often disagree, and awake ABP is a better predictor of future cardiovascular events than OBP [2,3].

There are two different patterns of discrepancy between awake ABP and OBP. One is the white coat effect (WCE), in which OBP is higher than awake ABP[4], resulting in some persons being classified as having white coat hypertension. The other is the masked hypertension effect (MHTE), in which awake ABP is higher than OBP[5]; a subset of those exhibiting a MHTE will have masked hypertension. Masked hypertension is associated with an increased risk of cardiovascular events, while white coat hypertension is associated with relatively lower risk[6]. Therefore, two people with the same OBP, one with a sizable WCE and the other with a sizable MHTE will, *ceteris paribus*, have different risks of a CV event.

In previous epidemiological studies comparing BP levels between OBP and awake ABP, the discrepancy of office systolic BP (OSBP) from awake ambulatory SBP was greater at older ages[7]. Those studies suggested that elderly subjects are more likely to exhibit the WCE (and less likely to exhibit the MHTE)[8] than non-elderly subjects. In contrast, for younger healthy subjects, awake ABP tends to be higher than office BP.[7] It seems to be normative for younger subjects to exhibit a MHTE[9]. It is important to know more precisely how the discrepancy between awake ABP and OBP varies with age, so that clinicians can make more informed decisions about which patients should be monitored with ABP measurement.

Aside from ABP measurement devices, home BP (HBP) devices that permit the self-measurement of BP have recently become widely available. Like 24-hr ABP, HBP has greater predictive value for cardiovascular events than OBP[10,11]. HBP monitoring is less expensive and more suited to long-term repeated use than 24-hr ABP monitoring.[12] Use of HBP in clinical practice is recommended in a joint statement of the American Heart Association and the American Society of Hypertension[13,14]. As with ABP, it is also important to know the pattern of discrepancy, if any, between HBP and OBP across age groups, given that HBP is becoming widely used in clinical practice.

The purpose of the present systematic review and meta-analysis is to elucidate the age gradients of OBP, ABP, and HBP, and inform clinical decision making about out-of-office BP monitoring by identifying the ages at which patients are more likely to exhibit a WCE or MHTE when using ABP or HBP.

Methods

Identification of papers

We performed a systematic review of ABP and home BP monitoring in PubMed at the end of January 2009. We identified publications that contained at least one of the following key terms: 24 hour (or 24-hour, 24-hr, 24-h, or ambulatory) blood pressure, white coat hypertension, masked hypertension, isolated office hypertension, reverse white coat hypertension, home (or self-measured or self-monitored) blood pressure; and also used one of the following terms: Epidemiology or general population. Additional papers were collected from the reference lists of the identified articles and reviews and a follow-up search for more recent publications (through April 2009). There were no available articles addressing this issue in the Cochrane library.

Paper selection

A flow chart summarizing the paper selection process is shown in Figure 1. The full text of those papers identified as potentially relevant on the basis of their titles and abstracts was reviewed by 2 independent investigators (J.I. and Y.I.). The criteria for papers to be included in the present systematic review were as follows: (1) The study evaluated OBP and either awake ABP or HBP, (2) awake ABP was measured using non-invasive upper-arm ABP monitors, or HBP was measured using an oscillometric semiautomatic or automatic upper-arm cuff device, and (3) the study was performed in a general population or with healthy volunteers (e.g., employees) including school children and youth. Studies were excluded from our analysis if they included: (1) pregnant women, (2) patients on hemodialysis, (3) patients with severe arrhythmia (4) patients on antihypertensive medication and/or (5) HBP data measured only in one day. Rater differences in the selection of articles were discussed, and one of the coauthors (J.E.S.) resolved any remaining discrepancies concerning article eligibility.

Data extraction

For the total sample and each subgroup characterized in a publication, the average age (or median age in the range), percentage of males, body mass index (BMI), and the methods of OBP, awake ABP, and HBP measurements for each study were abstracted. Means for OBP, awake ABP, and/or HBP and their standard deviations (SD) were also collected. The data of Hoshide et al.[15] were obtained from the original database, because the first author of the present meta-analysis was a coauthor.

Data synthesis

There were 2 articles in which HBP data were described separately for the morning and evening BP[16,17], for those cases, the overall average HBP and its standard deviation (SD) were calculated from the Ns, averages and SDs of morning and evening home BP. In the studies in which data were reported only for subgroups (such as men and women, dippers and non-dippers, those who had higher and lower urinary albumin excretion ratio, etc.), the average BP and SD for each age group (or the total sample) was calculated by combining the subgroup data.

Statistical analysis

The distributions of OBP, awake ABP, and HBP values and the differences in BPs are summarized as mean ± SD. As most of the accepted articles did not show SDs of the differences in office and awake BP, we calculated the SDs using the formula[18]: $[(\text{SD of office BP})^2 + (\text{SD of awake BP})^2 - 2\,r\,(\text{SD of office BP})\,(\text{SD of awake BP})]^{(0.5)}$; the r values were estimated from a study in which the individual-level data for all variables were available[15] (i.e. r(OSBP, awake ASBP)=0.62, r(office DBP, awake ADBP)=0.66, r(OSBP, home SBP)=0.78, r(ODBP, home DBP)=0.58). As the first step of the meta-analysis examining the differences in OBP and awake ABP, we performed a heterogeneity test. The estimates of differences in OBP and awake ABP exhibited significant heterogeneity across studies and age groups, so all data analyses were performed using an unstandardized random effects model. A meta-regression of the relationship of BP to age was estimated by restricted maximum likelihood (REML). This method iteratively estimates the heterogeneity (among age subgroups within and across studies) of residuals not attributable to differences in standard errors, computes weighted least squares estimates of the regression equation, re-estimates the heterogeneity for the residuals from this model, and repeats the process until it converges. The weight for each data point is the inverse of its estimated variance: $w_i=1/(\text{Variance}+SE_i^2)$, where variance equals the estimated sample heterogeneity and SE_i is the standard error of the BP mean. Statistical analyses were performed using SPSS (version 18.0, SPSS Inc. Chicago, Illinois, USA) metaanalysis and metaregression macros, created by David B. Wilson (http://mason.gmu.edu/~dwilsonb/ma.html)[19]. Meta-analysis estimates of the average difference between OBP and ABP/HBP and meta-regression estimates of the age trajectories are reported, along with their 95% confidence interval. The difference in age trajectories (slopes) between OBP and awake ABP, and between OBP and HBP were evaluated by estimating a weighted least squares mixed model with 1) separate intercepts and age coefficients for each BP measure, 2) weights equivalent to the final step of the separate meta-regression analyses (i.e., incorporating the heterogeneity parameter estimate), and 3) an unstructured error structure to adjust for the lack of independence within pairs of means (e.g., OBP mean and awake ABP mean come in pairs, obtained from the same sample of individuals). The statistical significance of the difference in age coefficients between two types of BP measurement was tested by comparing the ratio of the difference to its estimated standard error against the t-distribution with appropriate degrees of freedom. We conducted supplemental meta-regression analyses to evaluate whether the differences between OBP and ABP (or HBP) and their age gradients differ 1) by geographic region (Asia, the Americas, or Europe), 2) by the number of visits in which OBP was assessed (1 vs more than 1), or 3) by the method used to assess OBP (oscillometric device vs mercury sphygmomanometer). For all analyses, $p<0.05$ was considered statistically significant.

Results

Details of the studies included in the present systematic review are given in Tables 1 (OBP and ABP) [7,15,16,20–44] and 2 (OBP and HBP) [15–17,45–49]. The percentage of men, mean OBP, and mean awake ABP in each age group in the 27 selected studies [7,15,16,20–44] are shown in Table 1. The methods of OBP and awake ABP measurements in the selected studies are shown in Supplemental Table 1 (S1). In the meta-analysis of the 23 studies of adults (N=10249) [7,15,16,20–25,28,29,31–38,40–42,44], office systolic/diastolic BP [mean (95 % confidence intervals)] was 1.8 (1.8–1.9)/1.9 (1.8–2.0) mmHg higher than awake ABP (both P<0.001), but in the parallel analysis of the 5 studies of children and youth (N=1829) [26,27,30,39,43], awake ABP was 8.4 (8.2–8.5)/7.0 (6.9–7.1) mmHg higher than office BP (both P<0.001).

In the studies in which the data of men (13 studies, N=3562) [7,15,20,21,24–26,28,30–33,40] (Table S2) and women (11 studies, N=2585) [7,15,24–26,28,30–32,37,40] (Table S3) were separately available, the age gradients of OSBP/ODBP were steeper than those of awake ASBP/ADBP in both men and women (Figure 2; all $p<0.001$ for the difference in age gradient between corresponding measures of OBP and awake BP). The average OSBP/ODBP level became higher than the average awake ASBP/ADBP (i.e. a positive WCE) after the age of 51.3/42.7 years in men and 51.9/42.3 years in women. In women, OSBP tended to increase with age more steeply than in men (P=0.053), but there were no significant differences in the regression coefficients of awake SBP (P=0.38), ODBP (P=0.85), and awake DBP (P=0.16) between women and men.

Considering men and women combined, in studies that measured OBP and awake ABP (27 studies, N=12127) [7,15,16,20–44], OBP exceeded awake ABP after the age of 50.0/44.8 years. This discrepancy (WCE) increased with age (Figure 3), more so for SBP than for DBP (p for the difference between SBP and DBP=0.03). Additionally, the WCE assessed by awake ABP in systolic was determined by age and tended to be determined by only 1 visit for office BP measurement. Additionally the WCE in diastolic was determined by age, female gender, use of mercury sphygmomanometer and only 1 visit for office BP measurement (Table 2).

In the 4 studies in which office BP was measured using oscillometric devices [15,16,34,43], The estimated equations for WCE were: WCE by oscillometic devices in systolic = 0.20*age −10.0 and WCE by oscillometric devices in diastolic = 0.25*age−12.6. In the 18 studies (19 articles) in which office BP was measured using mercury sphygmomanometers [7,21–33,36,37,41,42,44], the estimated equations for WCE were: WCE by mercury sphygmomanometers in systolic = 0.29*age−14.0 and WCE by mercury sphygmomanometers in diastolic = 0.18*age−7.7.

In the studies in which OBP and HBP were measured (8 studies, N=4916) [15–17,45–49] (Table 3 and S4), OBP was higher than HBP at all ages (Figure 4). The age trajectory for OSBP was slightly steeper than that of HSBP (p for the difference = 0.16), while the ODBP age trajectory was nearly identical to that of HDBP (p for the difference = 0.93); thus the discrepancy between OBP and HBP (WCE assessed by HBP) gradually increased with age for systolic, but not for diastolic BP (p for the difference between SBP and DBP = 0.048) (Figure 3). WCE assessed by awake ABP increased more steeply with age than WCE assessed by HBP (p for the difference in regression coefficients; p=0.06 for systolic and p=0.003 for diastolic).

Finally, when comparing ABP and HBP in those studies in which OBP, awake ABP and HBP were all measured (2 studies, N=895) [15,16], awake ABP was higher than HBP at younger ages, becoming similar at the older age (Figure 5).

Discussion

The main findings of the present meta-analyses were as follows: (1) awake ABP was higher than OBP at younger ages, but OBP increased more steeply with age than did awake ABP, (2) OBP became higher than awake ABP after approximately age 50 for systolic and age 45 for diastolic BP in both men and women, (3) HBP was lower than OBP at all ages, and (4) HBP was lower than awake ABP at younger ages, and became similar to awake ABP in the older age.

Across studies, the WCE became greater (conversely, the MHTE became smaller) in elderly subjects. Because the WCE is a function of both ABP and OBP, there are two potential sources of the discrepancy: lack of increase in ABP or substantial increase in OBP. Perhaps age-related decreases in physical activity contributes to the flatter age trajectory of awake ABP; alternatively, anxiety in the context of visits to a doctor’s office/clinic[50] may increase with age, combining with age-related increases in arterial stiffness to create a steeper age trajectory of OBP.

Previous studies in general populations[51,52] have demonstrated that subjects with masked hypertension tend to be younger than those with white coat hypertension. On the other hand the subjects with masked hypertension were older than those with true normotension[51,52], because older subjects are likely to have higher awake ABP even among those with OBP less than 140/90 mmHg. These results suggest that masked hypertension is a blood pressure pattern which is most likely to be observed in middle aged subjects, while white coat hypertension is more common in elderly subjects.

On the other hand, HBP was lower than OBP at all ages. The discrepancy between OSBP and HSBP (i.e. WCE diagnosed by HBP) became slightly larger with increasing age, while that between ODBP and HDBP was consistent across ages. Unlike awake ABP, HBP and OBP are both measured in a resting condition, and therefore, the difference between OBP and HBP cannot be explained by differences in physical activity. The primary difference between HBP and OBP is that HBP is measured without doctors or nurses present, reducing the likelihood of a psychological BP elevation. Another difference between HBP and OBP is that OBP across these studies was measured only at 1 or 2 visits (S2) and the number of readings that contributed to an individual’s OBP estimate were fewer than those contributing to the HBP estimate. This is important because HBP readings in the first and second days of home assessment tend to be higher than those in the following days,[53] resulting in the average HBP over many days typically being lower than OBP measured only once or twice. From this perspective, HBP can be considered a resting BP in a more stabilized condition than OBP.

Some previous studies have reported that HBP is more predictive of future cardiovascular events than OBP[3,10], but the relationships of masked hypertension diagnosed by HBP with hypertensive target organ damage and cardiovascular events are controversial. In the Ohasama study (Japanese general population), masked hypertension diagnosed by HBP was associated with decreased glomerular filtration ratio[54], increased carotid intima media thickness[55], and the presence of silent cerebral infarcts[56] (but it should be noted that 69% of the subjects were taking antihypertensive medication[55]). Additionally, in the PAMELA study (Italian general population), masked hypertension diagnosed by HBP (measured only once in the morning and evening) was associated with increased risk of left ventricular mass index[51]. Contrary to those findings, Stergiou, et al.[57] reported in the Didima study (Greek general population) that masked hypertension diagnosed by HBP was not associated with future cardiovascular events, while white coat hypertension diagnosed by HBP was. However, despite their inconsistent results with respect to cardiovascular outcomes, the relationship of age to discrepancies between OBP and HBP were consistent across these three studies. Subjects with masked hypertension diagnosed by HBP were consistently older than those with white coat hypertension diagnosed by HBP, the opposite pattern from that found with awake ABP.

These findings suggest that the detection of masked hypertension and white coat hypertension is influenced by the interaction of age and the method of out-of-office BP monitoring used. HBP was lower than awake ABP in the non-elderly, and became similar to awake ABP in elderly subjects, probably due in part to decreased physical activity in the elderly subjects. Therefore, the prevalence of masked hypertension diagnosed by HBP will be smaller than that diagnosed by awake ABP in non-elderly subjects. Further research will be required to determine how physicians choose HBP or awake ABP in order to diagnose masked and white coat hypertension (or detect such effects).

Study limitations

Since we restricted the data included in this report to that of subjects not using antihypertensive medication, we also excluded data from unmedicated hypertensive subjects in those studies in which non-hypertensive and hypertensive subjects were not separated. Unfortunately, it was difficult to evaluate other potential confounding factors such as presence of diabetes, smoking, and alcohol use, because most of the articles used for this meta-analysis did not present these data for each age subgroup.

Conclusion

Awake ABP tends to exceed OBP at younger ages while the reverse is true after age 50, suggesting that masked hypertension is a blood pressure pattern which will most often be observed in middle aged subjects, while white coat hypertension will be more prevalent in elderly subjects. In contrast, HBP is lower than OBP at all ages and is also lower than ABP in the young and middle-aged.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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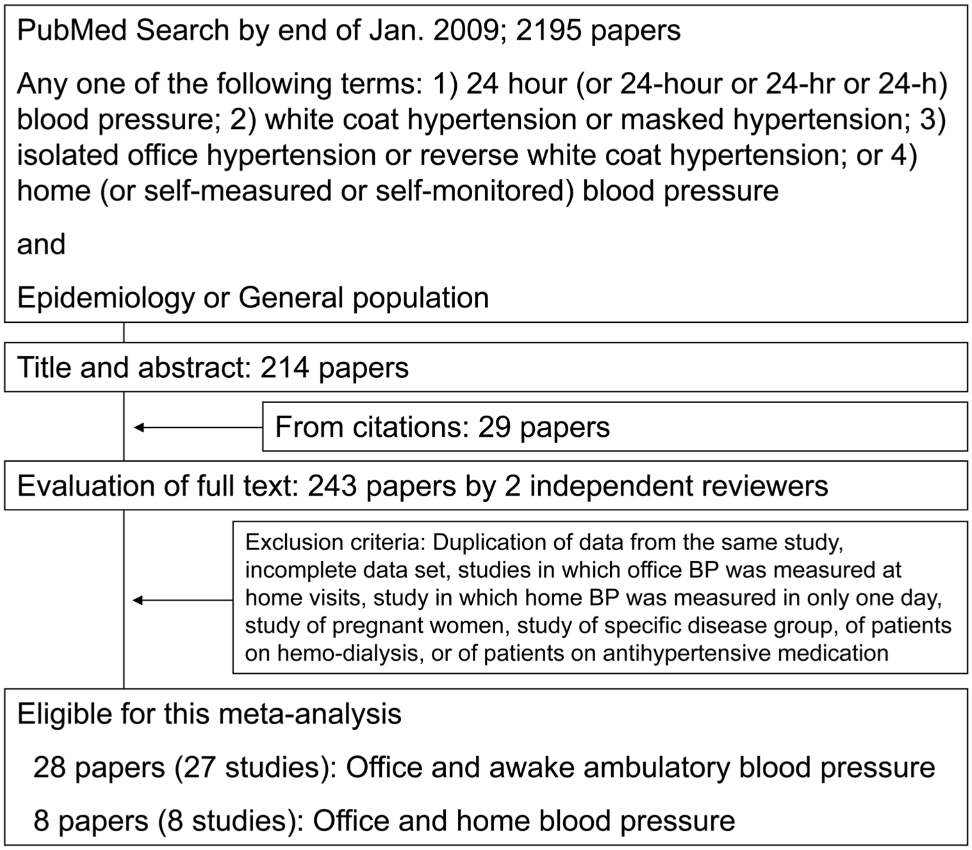

Figure 1.
Flow chart summarizing identification and selection of publications for systematic review

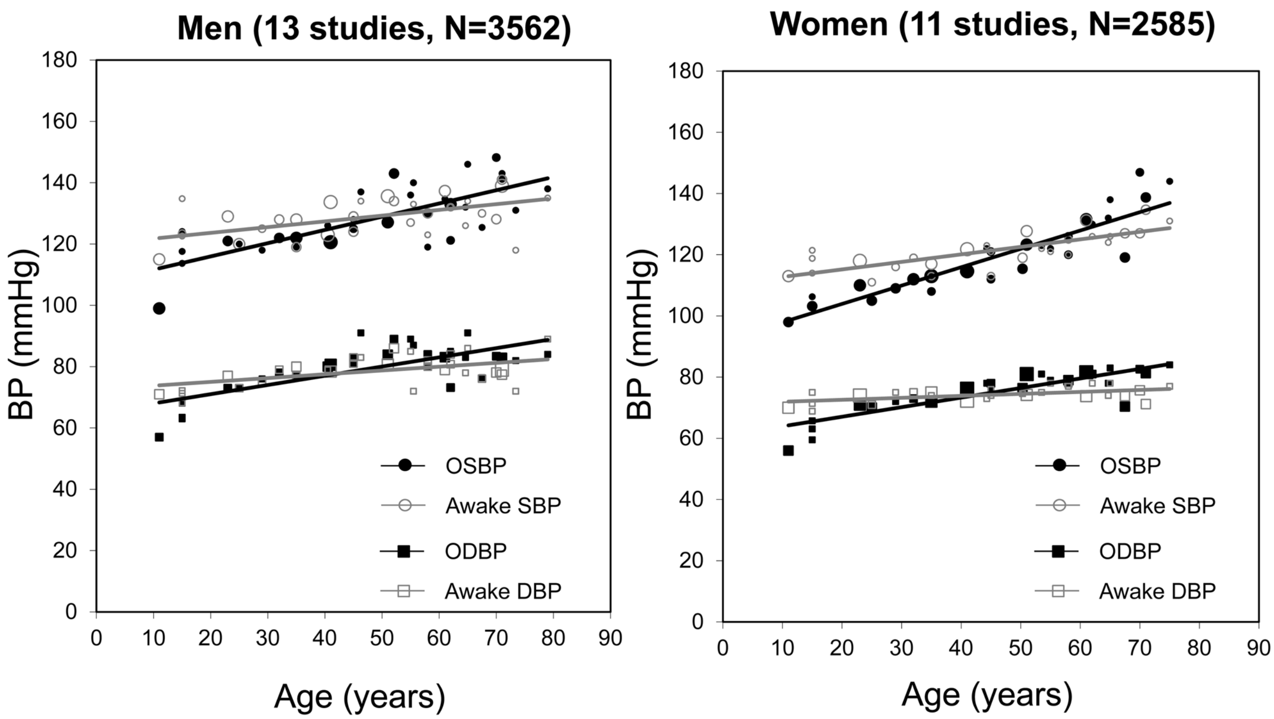

Figure 2. Scatter plots showing the relationships of office and awake ambulatory blood pressures to age in men and women

Data were available from 13 studies (N=3562) for men and 11 studies (N=2585) for women. Office SBP is shown as solid circle and black line; office DBP, open circle and gray line; awake ambulatory SBP, solid square and black line; awake ambulatory DBP, open square and gray line. The estimated equations for men are: office SBP=0.43*Age+107.3 (P[Age]<0.001); awake SBP=0.19*Age+119.9 (P<0.001); office DBP=0.30*Age+65.0 (P<0.001); awake DBP=0.12*Age+72.5 (P<0.001), and those for women are: office SBP= 0.60*Age+91.9 (P<0.001); awake SBP=0.25*Age+110.3 (P<0.001); office DBP=0.31*Age +60.8 (P<0.001); awake DBP=0.06*Age+71.3 (P=0.003). The ages at which office SBP/ DBP exceed awake BPs (i.e., the lines cross) are 51.3/42.7 years in men, and 51.9/42.3 years in women.

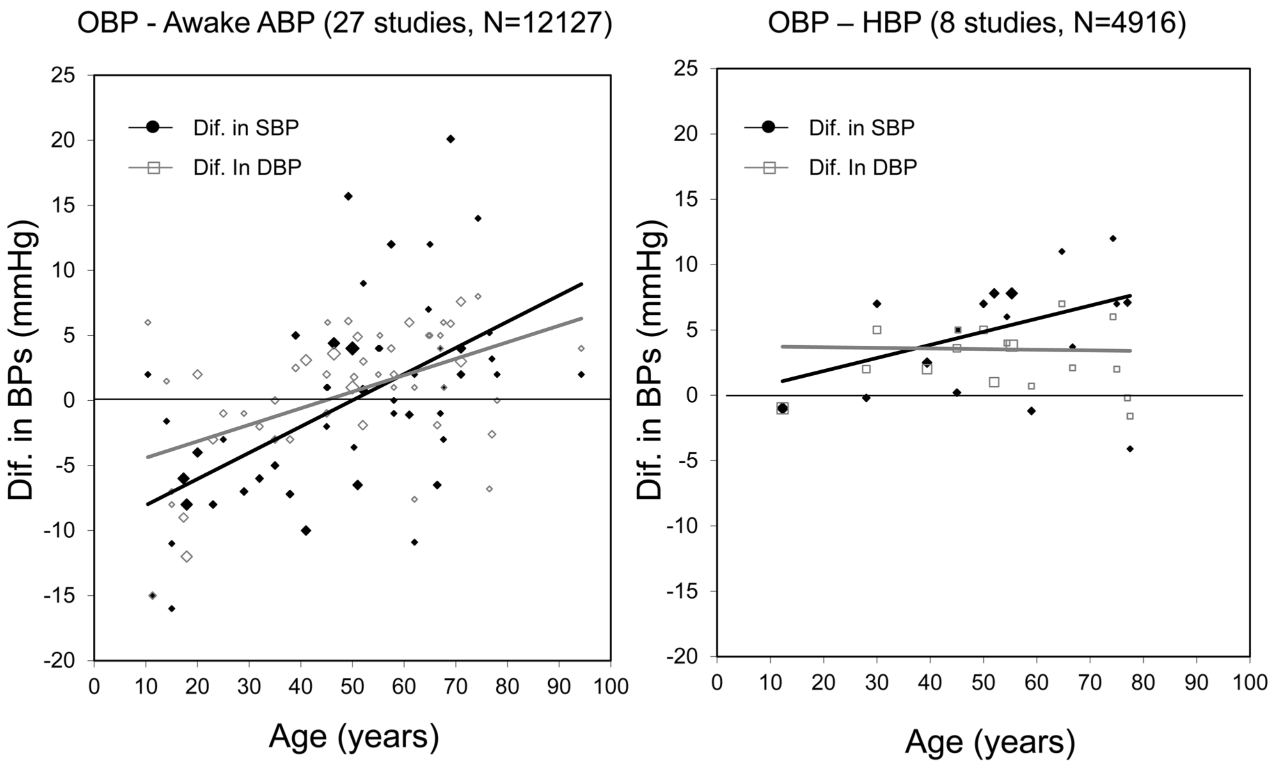

Figure 3. Scatter plots showing the relationship of the white coat effect, assessed by awake ambulatory blood pressure and by home blood pressures, to age

Data on the difference between office and awake blood pressure (white coat effect assessed by awake ambulatory blood pressure, WCE by ABP) were available from 27 studies (N=12127) and data on the difference between office and home blood pressure (white coat effect assessed by home blood pressure, WCE by HBP) were available from 8 studies (N=4916). The estimated equations are: WCE by ABP in systolic=0.20*Age−10.1 (P[Age]<0.001); WCE by ABP in diastolic=0.13*Age−5.7 (P<0.001); WCE by HBP in systolic=0.10*Age−0.2 (P=0.039); WCE by HBP in diastolic=(−0.005)*Age+3.8 (P=0.88).

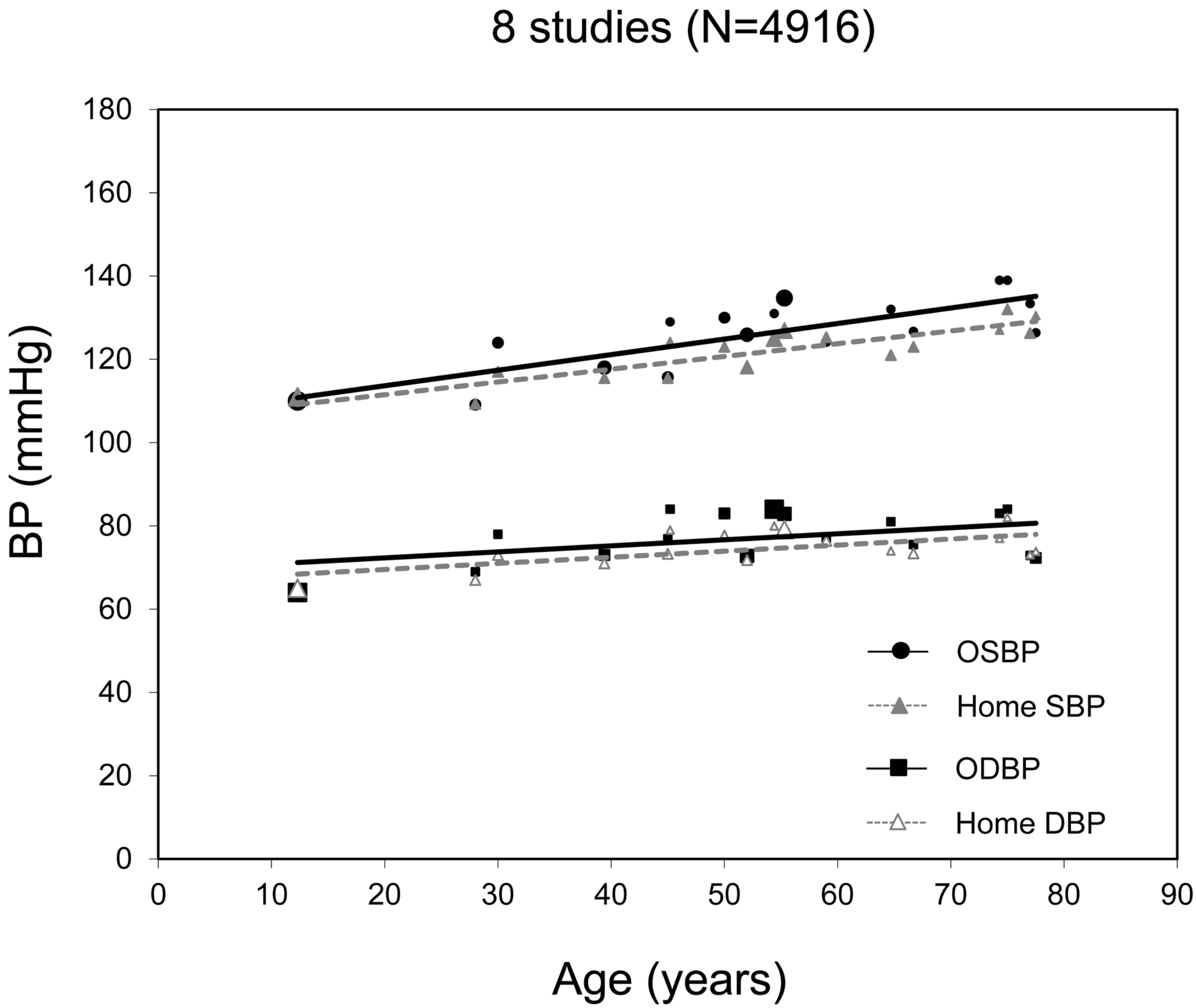

Figure 4. Scatter plots showing the relationship of office and home blood pressures to age

Data were available from 8 studies (N=4916). The estimated equations are: office SBP=0.37*Age+106.2 (P<0.001); home SBP=0.31*Age+105.4 (P<0.001); office DBP=0.15*Age+69.4 (P=0.047); and home DBP=0.15*Age+66.6 (P=0.002).

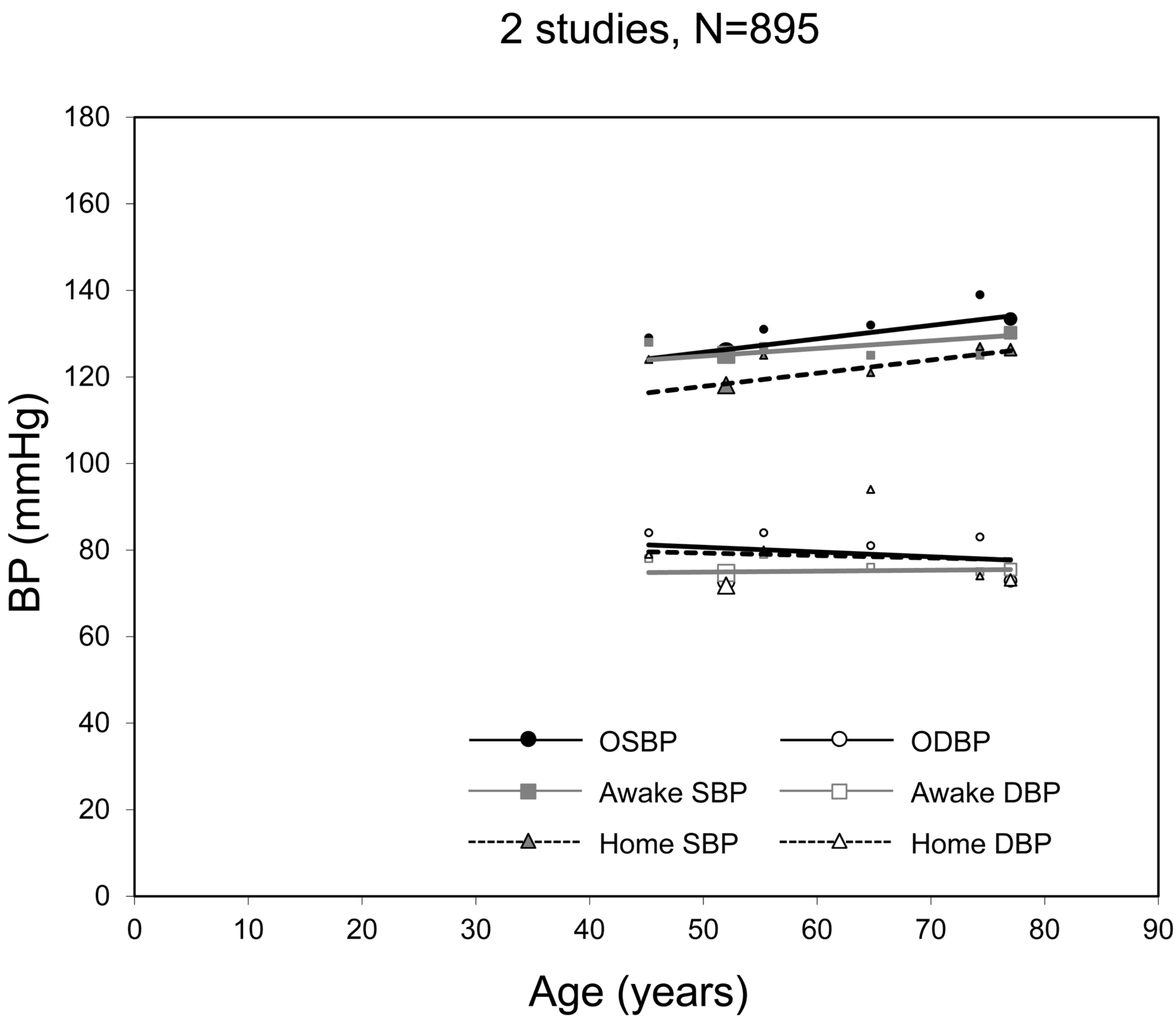

Figure 5. Scatter plots showing the relationships of office, awake ambulatory and home blood pressures to age

Data were collected from 2 articles (N=895). The estimated equations are: office SBP=0.31*Age + 110.2 (p[Age]<0.001); awake SBP=0.18*Age + 116.0 (p<0.001); home SBP=0.30*Age + 102.6 (p<0.001); office DBP=0.11*Age + 86.1 (p=0.60); awake DBP=0.02*Age + 73.8 (p=0.41); Home DBP=(−0.05)*Age + 81.9 (p=0.87).

Table 1

Office and awake blood pressure according to age groups in the selected studies.

First author	N. sub.	Age, y	Age range	Male, %	OSBP mmHg		ODBP mmHg		Awake SBP mmHg		Awake DBP mmHg	
					Mean	SD	Mean	SD	Mean	SD	Mean	SD
O'Brien[7]	281	23	(17, 29)	38.1	114	12.6	72	8.4	122	9.6	75	6.6
O'Brien[7]	272	35	(30, 39)	45.2	117	11.4	74	8.4	122	10.1	77	7.0
O'Brien[7]	164	45	(40, 49)	66.5	124	16.4	80	9.8	126	12.5	81	9.6
O'Brien[7]	98	62	(50, 73)	61.2	132	18.9	83	11.5	130	14.8	82	9.4
Enstrom[20]	164	52.1		100	143	18	89	11	134	14	86	9
Pearce[21]	34	62	(51, 72)	100	121.2	11.9	73.2	5.8	132.1	12.8	80.8	6.6
Hoegholm[22]	411	49.2		46.5	154.8	24.6	97.0	13.2	139.1	19.1	90.9	12.2
Mancia[23]	1438	46.4		49.2	127.4	17.0	82.3	9.8	123.0	11.0	78.7	7.9
Sega [24]	248	69.0		51.6	147.7	19.6	82.9	11.1	127.6	12.3	77.0	7.6
Nystrom[25]	95	32	(20, 44)	49.5	117	9.5	75	7.4	123	9.6	77	7.2
Nystrom[25]	105	58	(45, 70)	50.5	128	13.1	82	7.0	128	10.8	80	7.7
Lurbe[26]	228	11.3		50.9	99	11	56	9	114	8	71	6
Lambrechtsen[27]	559	20	(19, 21)	48	120	11	72	11	124	11	70	7
Rasmussen[28]	705	41	(41, 42)	47.8	117.4	13.5	78.3	9.7	127.4	12.9	75.2	8.4
Rasmussen[28]	682	51	(51, 52)	51.6	125.3	16.6	82.5	10.1	131.8	14.7	77.6	9.6
Rasmussen[28]	593	61	(61, 62)	50.9	133.2	17.7	82.4	10	134.3	15.2	76.4	9.1
Rasmussen[28]	400	71	(71, 72)	52.5	140.0	17.7	82.1	10.4	138.0	16.2	74.5	9.6
Manning[29]	265	39	(16, 68)	50.6	120	13.7	74.9	9.5	115.0	10.7	72.4	7.2
Meininger[30]	14	15	(15, 16)	35.7	110	10.5	67	6.6	126	10.3	74	6.3
Meininger[30]	10	15	(15, 16)	50.0	114	12.9	62	5.6	121	7.6	70	5.1
Meininger[30]	17	15	(15, 16)	58.8	109	9.8	63	7.5	120	7.1	70	7.1
Schettini[31]	140	25	(20, 29)	55.0	112	13.7	71	8.6	115	9.9	72	6.7
Schettini[31]	165	35	(30, 39)	46.7	113	15.0	75	10.1	116	10.4	75	8.5
Schettini[31]	141	45	(40, 49)	50.4	120	17.0	80	10.0	119	12.3	78	9.0
Schettini[31]	85	55	(50, 59)	44.7	128	20.7	83	12	124	12.7	81	9.9
Schettini[31]	41	65	(60, 69)	46.3	142	21.1	87	13	130	17.9	82	10.1

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First author	N. sub.	Age, y	Age range	Male, %	OSBP mmHg		ODBP mmHg		Awake SBP mmHg		Awake DBP mmHg	
					Mean	SD	Mean	SD	Mean	SD	Mean	SD
Hozawa[16]	593	52	(40, 64)	NA	125.9	17.2	72.8	10.6	125.1	13.2	74.7	8.3
Hozawa[16]	182	77	(65, 89)	NA	133.4	18.6	72.9	10.6	130.2	13.1	75.5	8.1
Kuznetsova[32]	71	29	(18, 40)	45.1	113	9.5	74	8.2	120	9.1	75	6.4
Kuznetsova[32]	37	58	(40, 76)	48.6	120	7.4	79	6.1	121	10.6	78	6.6
Bjorklund[33]	685	71	(69.7, 74.1)	100	143	17.1	82	8.9	139	16.1	79	7.9
Kawamura[34]	37	67.6	(65, 70)	62.2	125	23	78	12	128	13	72	7
Kawamura[34]	117	67	(65, 70)	35.0	138	24	84	14	139	21	80	11
Kawamura[34]	50	67	(65, 70)	40.0	136	20	81	11	132	19	76	9
Suzuki[35]	176	76.5		52.3	137.6	23.3	67.1	14.1	132.4	15.2	73.9	9.0
Salvetti[36]	225	57.5		52.4	138	14	85	8	126	10	81	8
Sherwood[37]	112	50.3		0	115.4	12.4	76.4	8.4	119.0	11.5	74.6	7.4
Jumabay[38]	100	67.7	(65, 70)	66.0	127	20	73	12	126	17	72	7
Jumabay[38]	103	94.3	(90, 99)	64.1	128	22	76	13	126	17	72	8
Jumabay[38]	33	100.4	(>=100)	75.8	134	23	80	14	132	22	74	11
Pijanowska[39]	59	14	(10, 18)	55.9	121.3	22.1	83.6	20.6	122.9	11.3	82.2	8.7
Goldstein[40]	157	66.4		41.4	121.7	14.0	72.9	8.8	128.2	11.6	74.8	6.6
Grewen[41]	314	37.9		49.7	122.4	15.3	77.5	11.0	129.6	14.7	80.5	9.1
Blanco[42]	68	78	(65, 91)	NA	123	12	72	9	121	11	72	7
Hoshide[15]	27	45.2	(40, 50)	44.4	129	19.1	84	10.7	128	16.9	78	9.6
Hoshide[15]	23	55.3	(50, 59)	47.8	131	19.7	84	10.2	127	15.7	79	10.0
Hoshide[15]	45	64.7	(60, 69)	48.9	132	15.4	81	10.0	125	12.9	76	8.3
Hoshide[15]	25	74.3	(70, 91)	44.0	139	22.0	83	10.2	125	18.8	75	8.4
Zhu[43]	532	17.9		49.8	110	11.5	58	6.9	118	7	70	6
Zhu[43]	410	17.3		44.1	113	10.1	61	8.1	119	6	70	5
Pierdomenico[44]	591	50		46.9	130	7	80	5	126	7	79	6

N.sub. Indicates number of subjects; OSBP, office systolic blood pressure; ODBP, office diastolic blood pressure; Awake SBP, awake systolic blood pressure; Awake DBP, awake diastolic blood pressure. Data are shown as mean and standard deviation (SD).

Table 2

Determinants of white coat effect assessed by awake blood pressure

	SBP				DBP			
	B	95%CI		P	B	95%CI		P
Age (deviation from 50 years), years	0.32	0.17	0.46	<0.001	0.19	0.12	0.26	<0.001
Percentage of male	−0.10	−0.24	0.04	0.16	−0.10	−0.16	−0.03	0.004
Asian vs. EU (Asian=1; 0=other)	−5.82	−19.25	7.62	0.40	5.59	−0.78	11.96	0.09
American vs. EU (American=1; 0=other)	−1.75	−6.84	3.34	0.50	−1.62	−4.04	0.80	0.19
Oscillometric device use for office BP (no=0; yes=1)	2.33	−8.25	12.91	0.67	−5.89	−10.89	−0.89	0.02
Number of visits for office BP (1=1; 0=more than 1)	5.09	−0.43	10.61	0.07	3.39	0.78	6.01	0.01
Definition of awake ABP (clock time=0; diary=1)	0.28	−4.25	4.80	0.91	−0.24	−2.38	1.91	0.83

Data were collected from 27 studies (N=12127). Data were calculated using meta-regression analysis weighted by the inverse of Variance+SE^2. Values of $p<0.05$ were considered statistically significant.

Table 3

Clinic and home blood pressure according to age groups in the selected studies.

First author	N. sub	AGE, y	Age range	OSBP mmHg		ODBP mmHg		Home SBP mmHg		Home DBP mmHg	
				Mean	SD	Mean	SD	Mean	SD	Mean	SD
Weisser[45]	147	30	(20, 40)	124	14	78	11	117	11	73	9
Weisser[45]	272	50	(40, 59)	130	15	83	11	123	14	78	11
Weisser[45]	84	75	(60, 90)	139	18	84	10	132	13	82	10
Hozawa[16]	593	52	(40, 64)	125.9	17.2	72.8	10.6	118.1	15.7	71.8	13.3
Hozawa[16]	182	77	(65, 89)	133.4	18.6	72.9	10.6	126.3	17.9	73.1	13.2
Stergiou[46]	143	28	(18, 37)	109.1	14.4	69.0	11.5	109.3	15.6	67.0	7.9
Stergiou[46]	145	45	(38, 52)	115.7	14.4	76.9	10.2	115.5	14.2	73.3	8.7
Stergiou[46]	131	59	(53, 64)	124.1	17	77.1	8.9	125.3	15.1	76.4	7.1
Stergiou[46]	143	77.5	(64, 91)	126.4	19.1	72.3	9.1	130.5	17.7	73.9	8.5
Tachibana[47]	101	66.7	(>50)	126.7	18	75.5	10	123.0	14	73.4	8
Niiranen[48]	1587	55.3		134.7	19.7	82.9	10.5	126.9	18.3	79.1	9.2
Hoshide[15]	27	45.2	(40, 49)	129	19.1	84	10.7	124	20.8	79	10.4
Hoshide[15]	23	54.4	(50, 59)	131	19.8	84	10.2	125	21.8	80	11.0
Hoshide[15]	45	64.7	(60, 69)	132	15.4	81	10.0	121	17.1	74	10.0
Hoshide[15]	25	74.3	(70, 91)	139	22.0	83	10.2	127	30.9	77	13.7
Kawabe[17]	503	39.4		118	14	73	11	115.5	19.1	71	14.1
Stergiou[49]	765	12.3		110	10	64	6	111	10	65	6

N.sub. Indicates number of subjects; OSBP, office systolic blood pressure; ODBP, office diastolic blood pressure; Home SBP, home systolic blood pressure; Home DBP, home diastolic blood pressure. Data are shown as mean and standard deviation (SD).