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ORIGINAL ARTICLE

Metabolic risk factors and masked hypertension in the general population: the Finn-Home study

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The association between masked hypertension and metabolic syndrome (MS) or insulin resistance is unclear. We investigated an untreated nationwide population sample ($n = 1582$, age 44–74 years). Duplicate office blood pressure (BP) measurements were taken on one visit and duplicate morning and evening home measurements were taken for 7 days. Masked hypertension was defined as office BP $< 140/90$ mm Hg with home BP $\geqslant 135/85$ mm Hg. Logistic regression analysis was used to determine the association between masked hypertension and metabolic risk factors. Age- and gender-adjusted odds ratios for metabolic disorder were 2.89 (1.87–4.47), 2.93 (2.15–3.97) and 1.68 (1.05–2.70) in white-coat hypertension, 3.39 (2.00–5.76), 3.86 (2.61–5.72) and 2.77 (1.63–4.70) in masked hypertension, and 7.38 (5.19–10.49), 6.45 (4.92–8.46) and 4.27 (3.00–6.08) in sustained hypertension using European Group for the Study of Insulin Resistance, harmonised MS and homeostasis model assessment of insulin resistance above the 80th percentile criteria. When home BP was used to define MS, masked hypertension moved close to sustained hypertension. The association between masked hypertension and metabolic disorders was related to home BP, body mass index and waist circumference. In conclusion, home BP appears to be a useful method to assess the risk of metabolic disorder. Masked hypertensives would benefit from the use of home BP in the definition of MS.

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Keywords: home blood pressure measurement; masked hypertension; white-coat hypertension; metabolic syndrome; homeostasis model assessment of insulin resistance

INTRODUCTION

Patients with hypertension frequently have other concomitant metabolic cardiovascular risk factors, including dyslipidemia, insulin resistance, central obesity and hyperglycemia. The clustering of these risk factors is called metabolic syndrome (MS). It was designed to help physicians identify patients who have multiple risk factors and are at increased risk of diabetes, cardiovascular events and all-cause mortality. MS is becoming increasingly common but its clinical significance is still somewhat controversial. It may not be superior to its individual components or specific prediction models in predicting cardiovascular events or development of diabetes.[1–5] Moreover, only office blood pressure (BP) is a component of MS in spite of the fact that out-of-office (home or ambulatory) BP is better correlated with metabolic risk factors and cardiovascular risk.[5–7]

Masked and white-coat hypertension may underlie the stronger relationship of home BP with metabolic risk factors. Masked hypertension is characterised by elevated home or ambulatory BP despite a normal office BP, whereas white-coat hypertensive patients have elevated BP in the office but normal home or ambulatory BP. Masked hypertension is a common phenomenon and has been associated with metabolic or lifestyle risk factors, which may contribute to its increased cardiovascular risk.[8–13] Previous studies have suggested that masked hypertensive patients are at risk of developing target organ damage,[8,9] cardiovascular disease[10–12] and new-onset diabetes mellitus[13] but disagreement between studies exist. Although patients with MS frequently have high-normal or elevated office, home and ambulatory BP levels, only a few studies have touched briefly on MS or insulin resistance in masked hypertension.[5,7,14–24] Most of these studies were based on selected patient groups[14–20,22–24] and only a few of them reported the criteria used to define MS.[14–16] The majority of them did not find any significant differences between BP subgroups.

The objective of the present study was to investigate metabolic disturbances in masked and white-coat hypertension in an unselected nationwide population using home BP measurement. We evaluated the association between BP categories and metabolic disorder using homeostasis model assessment of insulin resistance (HOMA-IR)[25] and two MS definitions: European Group for the Study of Insulin Resistance (EGIR) definition,[26] which requires the presence of hyperinsulinemia, and harmonised, the most recent definition.[4] We also investigated whether the association is independent of home BP level.

MATERIALS AND METHODS

Subjects

The study sample was drawn from the participants of a multidisciplinary epidemiological survey, the Health 2000 study, which was carried out in Finland from the fall of 2000 to the spring of 2001. A nationally representative sample of 8028 subjects aged 30 years or over was drawn from the population register using a two-stage stratified cluster sampling procedure. The stratification and sampling procedures and the methodology of the project have been previously described in detail.[27]

Of the subjects aged 44–74 years ($n = 4388$), 87% ($n = 3822$) agreed to participate in the interview and attend the health examination. In all, 2103 of these subjects were selected to participate in the home BP measurement substudy (Finn-Home study) on the basis of monitor

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availability (800 monitors) and willingness to participate.[28] Subjects who had not performed ⩾14 BP measurements at home ($n=43$), had missing laboratory or health examination data ($n=23$), or used antihypertensive medication ($n=472$) were excluded from the study. The study population thus consisted of 1582 subjects aged 44–74 years. Study participants had lower office systolic BP levels and were less often current smokers than non-participants. In addition, the prevalence of diabetes was lower among participants than among non-participants (Supplementary Table).

The study protocol of the Health 2000 survey was approved by the Epidemiology Ethics Committee of the Helsinki and Uusimaa hospital region, and all participants gave signed informed consent.

BP measurements

Office BP was measured by a trained nurse using a conventional calibrated mercury sphygmomanometer. Measurements were taken in the sitting position after a 10-min rest. The last 5-min of rest were spent in the measuring room with the cuff around the right upper arm. A cuff with an appropriate bladder width was used. Systolic BP and diastolic BP were defined according to Korotkoff sounds I and V. Office BP was determined as the mean of two measurements performed at a 2-min interval.

Home BP was self-measured with a validated, automatic oscillometric device (Omron model HEM-722C, Omron Corporation, Tokyo, Japan) according to the current guidelines.[29,30] After receiving written instructions and individual guidance, study participants took duplicate self-measurements every morning (between 0600 and 0900 h) and every evening (between 1600 and 2100 h) for 7 consecutive days. Measurements were taken in the sitting position at an approximately 2-min interval. Preparations for self-measurement of BP were the same as for office BP.[29] Home BP was determined as the mean of 14 duplicate measurements (28 measurements). The mean number of performed measurements was 26.7 ± 3.7.

Classifications

Subjects were divided into four subgroups using office and home BP values: (1) normal office and home BP; (2) normal office BP with elevated home BP, that is, masked hypertension; (3) elevated office BP with normal home BP, that is, white-coat hypertension; and (4) elevated office and home BP, that is, sustained hypertension. The currently recommended cutoff levels of 140/90 and 135/85 mm Hg,[29,31] respectively, were used to define office and home hypertension.

Current smoking was defined as a daily use of tobacco products. Diabetes was defined as fasting serum glucose level $\geqslant 7.0\,\mathrm{mmol\,l^{-1}}$ and/or a history of use of oral hypoglycemic agents or insulin injection. Hypercholesterolemia was classified according to the fasting serum total cholesterol level ($\geqslant 7.0\,\mathrm{mmol\,l^{-1}}$) and/or use of statins. To determine heavy drinking, we selected a definition that is commonly used in Finland.[32] Weekly alcohol intake of more than 24 units in men and 16 units in women was considered excessive consumption. One alcohol unit contains an average of 12 g of 100% alcohol.

Metabolic disorders

MS was defined according to the EGIR or harmonised criteria.[4,26] EGIR defines insulin resistance as the top 25% of the fasting insulin values among nondiabetic individuals. The diagnosis of MS requires insulin resistance plus two or more of the following risk factors: central obesity (waist circumference ⩾94 cm in men and ⩾80 cm in women), hypertension (office BP ⩾140/90 mm Hg), elevated fasting serum glucose ($\geqslant 6.1\,\mathrm{mmol\,l^{-1}}$), dyslipidemia (serum triglycerides $\geqslant 2.0\,\mathrm{mmol\,l^{-1}}$, high-density lipoprotein (HDL)-cholesterol $<1.0\,\mathrm{mmol\,l^{-1}}$ or treated for dyslipidemia). The harmonised definition of MS requires three or more of the following five risk factors: central obesity (waist circumference ⩾94 cm for men and ⩾80 cm for women), hypertension (office BP ⩾130/85 mm Hg), elevated fasting serum glucose ($\geqslant 5.6\,\mathrm{mmol\,l^{-1}}$ or treatment), elevated serum triglyceride level ($\geqslant 1.7\,\mathrm{mmol\,l^{-1}}$) or low HDL-cholesterol (<1.0 in men and $<1.3\,\mathrm{mmol\,l^{-1}}$ in women).

In home BP-based definitions, a 5/5 mm Hg lower cutoff level was used for home BP than for office BP, that is, cutoff 125/80 mm Hg for harmonised definition and 135/85 mm Hg for EGIR definition.[31]

Elevated BP is one component of MS.[5,31] Therefore, we also assessed the presence of pure metabolic disturbance as decreased insulin sensitivity. HOMA-IR was calculated using the following formula: (fasting glucose ($\mathrm{mmol\,l^{-1}}$) × fasting insulin ($\mu\mathrm{U\,ml^{-1}}$))/22.5.[25] Decreased insulin sensitivity was defined as HOMA-IR greater than 80th percentile in non-diabetic population (2.93 for men and 2.36 for women).

Statistical analyses

Results are reported as mean ± standard deviation or percentage. The statistical significance of between-group differences was tested by analysis of variance with *post hoc* pairwise comparisons (Tukey test) with age and gender as covariates. Before the analyses, the skewed distribution of triglycerides, insulin and HOMA-IR was corrected with logarithmic transformation. The associations between metabolic disorder and masked, white-coat and sustained hypertension were studied with multivariate logistic regression model using (1) age and gender, (2) age, gender, systolic home BP and diastolic home BP and (3) age, gender, systolic and diastolic home BP, body mass index and waist circumference (for high HOMA-IR) as covariates. To find out the association between HOMA-IR and its determinants, we used two multivariate regression models, one including age, gender, systolic and diastolic home BP and body mass index, and the other including also the information on white-coat, masked and sustained hypertension as independent variable. A *P*-value <0.05 was considered statistically significant. All statistical analyses were conducted with SAS version 9.1 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Population characteristics

Of the 1582 participants, 748 (47.3%) were male and 834 (52.7%) were female. In all, 27.1% of participants (30.9% of men and 23.6% of women) were diagnosed as hypertensive according to both office and home BP; 8.1% of participants (10.7% of men and 5.8% of women) were masked hypertensive and 15.0% of participants (16.3% of men and 13.8% of women) had white-coat hypertension. All participants were Caucasian. Table 1 shows the demographic, lifestyle and clinical characteristics of each subgroup. The normotensive group was younger, included a lower proportion of men and had lower rates of metabolic risk factors than the three other groups.

White-coat hypertensive patients had diabetes less often than masked hypertensives. White-coat hypertensives also had a significantly lower HOMA-IR and fasting insulin level than sustained hypertensives. Masked and sustained hypertensive individuals had greater waist circumference and lower HDL cholesterol than white-coat hypertensives or normotensives. In masked hypertension, the proportion of smokers was greater than in the three other groups. Masked and sustained hypertensive patients exceeded the recommended limits of alcohol consumption more often than normotensives.

Masked hypertensive patients had office BP values that, although in normal range, were higher than those of true normotensives. Likewise, the home BP levels of white-coat hypertensive patients were higher than those of normotensives.

MS

The office BP-based prevalence of MS ranged from 18.1% based on the EGIR definition to 43.5% based on the harmonised definition. Normotensive individuals had a significantly lower prevalence of MS than the other groups when EGIR or harmonised criteria was used (Table 2). The office BP-based prevalence of metabolic disorders increased from normotension to white-coat, masked and sustained hypertension, respectively. Sustained hypertensive individuals met harmonised MS criteria significantly more often than white-coat hypertensives and EGIR criteria more often than white-coat or masked hypertensives (Table 2).

We also investigated the association between office BP-based MS and BP categories using a logistic regression model (Table 3). The age- and gender-adjusted odds ratios increased progressively from normotension over white-coat and masked hypertension to sustained hypertension. After adjustment for systolic and diastolic home BP, all associations were attenuated.

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Table 1. Characteristics of the study population

	Normotension	*White-coat hypertension*	*Masked hypertension*	*Sustained hypertension*	P-*value*[a]
n (%)	789 (49.9)	237 (15.0)	128 (8.1)	428 (27.1)	
Men (%)	39.9	51.5**	62.5***	54.0***	<0.001
Age (years)	53.2 (7.4)	55.9 (8.3)***	56.5 (8.5)***,†††	58.3 (8.8)***,††	<0.001
Office systolic BP[b] (mm Hg)	120.6 (10.6)	145.9 (10.2)	130.0 (7.2)	155.6 (16.7)	<0.001
Office diastolic BP[b] (mm Hg)	76.8 (7.1)	88.2 (7.7)	80.8 (6.8)	92.0 (9.6)	<0.001
Home systolic BP[b] (mm Hg)	114.0 (9.9)	124.1 (7.3)	140.4 (7.9)	147.9 (13.6)	<0.001
Home diastolic BP[b] (mm Hg)	73.3 (5.9)	77.8 (4.9)	85.1 (6.0)	88.8 (7.3)	<0.001
Waist circumference (cm)	88.6 (11.3)	92.1 (11.9)*	98.3 (13.1)***,†††	98.8 (11.6)***,†††	<0.001
Current smokers (%)	21.7	15.2	35.9***,†††	20.1§§	<0.001
Excessive alcohol consumption (%)	4.6	7.7	13.3**	10.0***	<0.001
Diabetes (%)	1.3	4.2**	11.7***,††	7.5***	<0.001
Serum glucose (mmol l^{-1})	5.3 (0.6)	5.6 (1.0)	5.6 (1.1)	5.8 (1.8)***	<0.001
Hypercholesterolemia (%)	21.6	27.9	28.9	35.3**	<0.001
HDL-cholesterol (mmol l^{-1})	1.4 (0.4)	1.4 (0.4)	1.3 (0.4) **,†	1.3 (0.4) **,†	<0.001
Serum triglycerides (mmol l^{-1})	1.4 (0.7)	1.6 (1.1)**	1.8 (1.1)***	1.8 (1.1)***	<0.001
Serum insulin (mU l^{-1})	6.5 (4.2)	7.8 (5.8)***	9.1 (6.4)***	10.0 (6.1)***,†††	<0.001
HOMA-IR	1.6 (1.1)	2.0 (1.7)***	2.3 (1.8)***	2.6 (2.1)***,†††	<0.001

Abbreviations: BP, blood pressure; HDL, high-density lipoprotein; HOMA-IR, homeostasis model assessment of insulin resistance. Data are shown as mean (s.d.) or percentage for each subgroup. *$P<0.05$ vs normotension. **$P<0.01$ vs normotension. ***$P<0.001$ vs normotension. †$P<0.05$ vs white-coat hypertension. ††$P<0.01$ vs white-coat hypertension. †††$P<0.001$ vs white-coat hypertension. §§$P<0.01$ vs masked hypertension. Analyses were adjusted for age and gender. [a]Comparison between all four groups. [b]All pair-wise group comparisons $P<0.001$.

Table 2. Prevalence of metabolic disorders in blood pressure categories

	Whole population	*Normotension*	*White-coat hypertension*	*Masked hypertension*	*Sustained hypertension*	P-*value*[a]
Harmonised based on office BP (%)	43.5	24.4	50.6***	58.6***	70.5***,†††	<0.001
Harmonised based on home BP (%)	42.0	22.8	41.4***	65.6***,†††	70.5***,†††	<0.001
EGIR based on office BP (%)	18.1	6.9	18.9***	22.1***	38.5***,†††,§§§	<0.001
EGIR based on home BP (%)	17.5	6.9	10.1	31.9***,†††	38.5***,†††	<0.001
High HOMA-IR (%)	20.0	12.3	16.2	28.2***,†	35.4***,†††	<0.001

Abbreviations: BP, blood pressure; EGIR, European Group for the Study of Insulin Resistance; HOMA-IR, homeostasis model assessment of insulin resistance. Data are shown as percentage for each subgroup. A 5/5 mm Hg lower cutoff level was used for home blood pressure than for office BP, that is, cutoff 125/80 mm Hg for harmonised definition and 135/85 mm Hg for EGIR definition. Elevated HOMA-IR was defined as greater than 80th percentile (2.93 for men and 2.36 for women). ***$P<0.001$ vs normotension. †$P<0.05$ vs white-coat hypertension. †††$P<0.001$ vs white-coat hypertension. §§§$P<0.001$ vs masked hypertension. Analyses were adjusted for age and gender. [a]Comparison between all four subgroups.

As high BP is one component of MS, we also investigated the presence of at least two metabolic risk factors (fasting insulin level in the upper quartile and central obesity (waist circumference $\geqslant$94 cm for men and $\geqslant$80 cm for women), elevated fasting serum glucose ($\geqslant$6.1 mmol l^{-1}) and dyslipidemia (serum triglycerides $\geqslant$2.0 mmol l^{-1}, HDL-cholesterol $<$1.0 mmol l^{-1} or treatment)) in BP subgroups. The prevalence of metabolic risk factors still increased from normotension to white-coat, masked and sustained hypertension (12.5%, 18.9%, 31.9% and 38.5%, respectively). Age- and gender-adjusted odds ratios (confidence intervals) were 1.48 (1.00–2.21) for white-coat hypertension, 2.89 (1.84–4.55) for masked hypertension and 3.79 (2.80–5.13) for sustained hypertension ($P<0.001$). The associations lost statistical significance after adjustment for systolic and diastolic home BP.

Home BP in MS

We also assessed the use of elevated home BP instead of office BP as one component of MS. The home BP-based prevalence of MS was 17.5% for EGIR and 42.0% for harmonised definition. In normotensive and sustained hypertensive subjects, similar prevalences were found when home or office BP was used (Table 2). The home BP-based prevalences of harmonised and EGIR MS were 7.0 and 9.8% higher in masked hypertensives, and 9.2 and 8.8% lower in white-coat hypertensives than the office BP-based prevalences. Similarly, the age- and gender-adjusted odds ratios for the presence of MS increased in masked hypertension and decreased in white-coat hypertension when home BP instead of office BP was used to define MS (Table 3). After adjustment for systolic and diastolic home BP, the increased risk remained significant only for home BP-based EGIR definition.

Insulin resistance

The prevalence of elevated HOMA-IR, determined as greater than 80th percentile in non-diabetic population, increased from normotension to white-coat, masked and sustained hypertension (Table 2). High HOMA-IR was significantly more common in masked and sustained hypertension than in normotension or white-coat hypertension. Masked and white-coat hypertensions were not significantly related to high HOMA-IR after adjustment for age, gender, and either systolic and diastolic home BP or waist circumference (Table 3). We also investigated the factors that were independently associated with HOMA-IR as a continuous using a multiple regression model (Table 4). When age, gender, body mass index, and systolic and diastolic home BP were included in the model, systolic home BP was an independent determinant of HOMA-IR. The addition of BP categories in the model did not increase the R^2 (0.311) compared with a model not including BP categories (0.306).

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Table 3. Odds ratios for metabolic disorder in masked, white-coat and sustained hypertension

A

Variable	*EGIR based on office BP*		*EGIR based on home BP*	
	Odds ratio (95% CI)[a]	*Odds ratio (95% CI)*[b]	*Odds ratio (95% CI)*[a]	*Odds ratio (95% CI)*[b]
Normotension	1	1	1	1
White-coat hypertension	2.89 (1.87–4.47)	2.39 (1.52–3.74)	1.38 (0.82–2.31)	1.15 (0.68–1.94)
Masked hypertension	3.39 (2.00–5.76)	1.97 (1.06–3.67)	5.55 (3.40–9.05)	3.29 (1.83–5.93)
Sustained hypertension	7.38 (5.19–10.49)	3.59 (2.07–6.25)	7.35 (5.16–10.45)	3.66 (2.10–6.39)

B

Variable	*Harmonised based on office BP*		*Harmonised based on home BP*	
	Odds ratio (95% CI)[a]	*Odds ratio (95% CI)*[b]	*Odds ratio (95% CI)*[a]	*Odds ratio (95% CI)*[b]
Normotension	1	1	1	1
White-coat hypertension	2.93 (2.15–3.97)	2.19 (1.58–3.01)	2.16 (1.58–2.95)	1.36 (0.98–1.89)
Masked hypertension	3.86 (2.61–5.72)	1.68 (1.03–2.72)	5.63 (3.75–8.45)	1.49 (0.90–2.45)
Sustained hypertension	6.45 (4.92–8.46)	2.19 (1.40–3.41)	6.96 (5.29–9.15)	1.26 (0.80–1.98)

C

Variable	*High HOMA-IRm*		
	Odds ratio (95% CI)[a]	*Odds ratio (95% CI)*[b]	*Odds ratio (95% CI)*[c]
Normotension	1	1	1
White-coat hypertension	1.68 (1.05–2.70)	1.39 (0.86–2.26)	1.30 (0.78–2.19)
Masked hypertension	2.77 (1.63–4.70)	1.64 (0.88–3.07)	1.24 (0.63–2.44)
Sustained hypertension	4.27 (3.00–6.08)	2.12 (1.19–3.75)	1.93 (1.05–3.56)

Abbreviations: BP, blood pressure; CI, confidence interval; EGIR, European Group for the Study of Insulin Resistance; HOMA-IRm, homeostatic model assessment of insulin resistance. Home blood pressure cutoff level of 135/85 mm Hg was used for EGIR and 125/80 mm Hg for harmonised criteria. Elevated HOMA-IR was defined as greater than 80th percentile (2.93 for men and 2.36 for women). The *P*-value shows comparison between all four groups. [a]Adjusted for age and gender. [b]Adjusted for age, gender, systolic home BP and diastolic home BP. [c]Adjusted for age, gender, systolic and diastolic home BP, body mass index and waist circumference.

Table 4. Determinants of HOMA-IR in multivariate regression analysis

Variable	*Beta coefficient*	*Standard error*	t-*value*	P-*value*
Gender (male)	0.1071	0.0283	3.78	<0.001
Age (years)	0.0045	0.0019	2.31	0.02
Systolic home BP (mm Hg)	0.0052	0.0015	3.40	<0.001
Diastolic home BP (mm Hg)	−0.0007	0.0029	−0.24	0.8
Body mass index (kg m$^{-2)}$	0.0705	0.0036	19.73	<.0001

Abbreviations: BP, blood pressure; HOMA-IR, homeostasis model assessment of insulin resistance. Model $R^2 = 30.6\%$, F(5,1557) = 137.2, $P < 0.001$.

DISCUSSION

MS refers to a clustering of risk factors that increase the risk of cardiovascular disease and diabetes. Although home BP is more closely related to cardiovascular risk, office BP is still used to define MS. Some of the previous studies have suggested that patients with elevated home BP despite a normal office BP, that is, masked hypertension, have metabolic cardiovascular risk factors and are at risk of developing cardiovascular disease and type 2 diabetes.[8–13] However, the relationship between masked hypertension and metabolic disorder has been unclear. The present study investigated a large general population and used EGIR and harmonised MS definitions, and HOMA-IR. The rates of metabolic risk factors increased from normotension to white-coat, masked and sustained hypertension. Regardless of its definition, metabolic disorder was more common in masked and white-coat hypertension than in normotension. When home BP instead of office BP was used in the definition of MS, masked hypertension moved close to sustained hypertension, whereas white-coat hypertension remained intermediate between normotension and sustained hypertension. Association between masked hypertension and metabolic disorder was related to home BP level, body mass index and waist circumference.

In previous studies, the prevalence of MS has ranged from 20 to 84% among masked hypertensive individuals.[14–20] Although the prevalence of MS varies widely depending on the definition used, only three studies reported criteria for the syndrome.[14–16] Only a Korean study defined masked hypertension using home BP measurement but it investigated treated hypertensive patients.[17–19] The majority of the previous studies did not find any significant differences in MS between the BP groups[14,16–20] but only one study investigated all four BP subgroups. That study performed ambulatory BP measurement on 328 untreated, non-

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diabetic patients and used the National Cholesterol Education Programme's Adult Treatment Panel III criteria for MS. The proportion of the syndrome was higher in masked (29%) and sustained hypertension (30%) than in normotension (12%) or white-coat hypertension (17%).[15]

The prevalence of harmonised MS was similar in the untreated Finn-Home study population and in the larger sample of the Health 2000 survey.[1] In the present study, MS was two to three times more common in masked and white-coat hypertension than in normotension when EGIR or harmonised definition was used. Even though office BP is one component of the MS definitions, the prevalence of MS was usually higher in masked than in white-coat hypertension. In line with our results, previous studies have shown that metabolic risk factors and cardiovascular risk are more closely related to home than office BP.[5–7] It should be noted that masked hypertension is associated with adverse lifestyles, such as smoking, high alcohol consumption and obesity, compared with white-coat hypertension or normotension. These risk factors are related to MS components and may modify the associations between BP categories and metabolic disorder.[3,33]

Insulin resistance and compensatory hyperinsulinemia are common in hypertension and they may have a role in the development of cardiovascular disease in hypertensive patients. HOMA-IR, a surrogate measure of insulin resistance, has been associated with cardiovascular risk independently of hypertension.[33] Masked hypertension has been frequently associated with elevated fasting glucose levels, impaired glucose tolerance and diabetes,[8–13] and two population-based studies have suggested that masked hypertensives have elevated fasting insulin levels.[8,11] However, only a few studies have assessed HOMA-IR in masked hypertension.[21–24] A Japanese population-based study found only nonsignificant differences between masked hypertension, defined with home BP and the other BP groups.[21] Another study performed ambulatory BP measurement on 76 untreated, non-diabetic patients and observed significantly higher HOMA-IR in masked, white-coat and sustained hypertension than in normotension.[23] In addition, in a population-based study of untreated elderly Swedish men, masked and sustained hypertension had impaired insulin sensitivity compared with normotension.[11] This study used euglycemic hyperinsulinemic clamp, a direct measurement of insulin sensitivity. The present study observed that the risk of elevated HOMA-IR increased from normotension over white-coat and masked hypertension to sustained hypertension.

Although hypertension categories were associated with metabolic disorder, the associations were attenuated when home BP level was included in the regression models. When we assessed the risk of only metabolic risk factor clustering (fasting insulin level in the upper quartile and central obesity, elevated fasting serum glucose or dyslipidemia) in BP subgroups, all associations became nonsignificant after adjustment for home BP. Moreover, when assessing the factors that were independently related to HOMA-IR, inclusion of BP categories did not improve the explanatory power of the model. Masked hypertensive patients in particular could benefit from the use of home BP in the definition of MS. Only one previous study has assessed the use of home BP in the definition of MS. In a Japanese population-based study, elevated home BP was significantly associated with the clustering of metabolic risk factors but office BP was not when Adult Treatment Panel III or Japanese criteria was used.[7] When we used home BP to define MS in the present study, masked hypertension moved close to sustained hypertension. The home BP-based prevalences of harmonised and EGIR MS were 7–10% higher in masked hypertensives and 9% lower in white-coat hypertensives than the office BP-based prevalences.

The present study has both its strengths and limitations. It was performed in a large nationwide population sample and home BP was measured over a period of 1 week using currently recommended measurement protocol. However, only two office BP measurements were taken at one visit. This may have affected the reliability of the subgroup classification and led to an underestimation of the prevalence of masked hypertension and overestimation of the prevalence of white-coat hypertension. It is possible that multiple office readings might have increased the association between white-coat hypertension and metabolic disorder. However, home BP measurement provides a greater number of readings than office measurement in clinical practice. Study participants had slightly lower systolic office BP levels and were less often smokers or diabetic than non-participants, which may have attenuated between-group differences. These results may not necessarily be applicable to other populations as the Finnish population is relatively homogenous and Caucasian. The present study was a cross-sectional study so no causal inferences can be drawn from the relationships between variables.

CONCLUSIONS

In a general population, the risk of metabolic disorder increases from normotension over white-coat, and masked hypertension to sustained hypertension. When home BP instead of office BP is used in the EGIR and harmonised definitions, the prevalence of MS in masked hypertensives is 7–10% higher and close to that of sustained hypertensives. Association between masked hypertension and metabolic disorders is related to home BP, body mass index and waist circumference. Elevated home BP could be a useful method to assess the risk of metabolic risk factor clustering.

What is known about topic

- Home blood pressure (BP) is better correlated with metabolic risk factors than office BP.
- The association between masked hypertension and metabolic syndrome or insulin resistance is unclear.

What this study adds

- The risk of metabolic disorder increases from normotension over white-coat, and masked hypertension to sustained hypertension.
- When home BP instead of office BP is used in the European Group for the Study of Insulin Resistance and harmonised definitions, the risk of metabolic syndrome in masked hypertensives is close to that of sustained hypertensives.
- The association between masked hypertension and metabolic disorders is related to home BP, body mass index and waist circumference.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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