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Are personality traits associated with white coat and masked hypertension?

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Abstract

Objectives—Anxiety and other psychological dispositions are thought to be associated with blood pressure. This study tests whether personality traits have long-term associations with masked and white coat effects.

Methods—A community-based sample of 2,838 adults from Sardinia (Italy) completed the Revised NEO Personality Inventory and seven years later blood pressure was assessed in the clinic and with ambulatory monitoring. Logistic regressions were used to test whether anxiety, neuroticism, extraversion, openness, agreeableness, and conscientiousness predicted the white coat and masked hypertension phenomena. Age, sex, and antihypertensive medication use were tested as moderators.

Results—Significant interactions were found between personality traits and antihypertensive medications in predicting masked and white coat effects. Only among those taking antihypertensive medication, higher anxiety was associated with a higher risk of pseudo-resistant hypertension due to white coat effect (OR = 1.39, 95%CI = 1.01–1.91) and higher conscientiousness was associated with a lower risk of masked uncontrolled hypertension (OR = 0.70, 95%CI = 0.49–0.99). There were no significant interactions with age or sex.

Conclusions—Among those on antihypertensive medications, anxious individuals were more likely to have pseudo-resistant hypertension due to white coat effect and less conscientious individuals were at increased risk of masked uncontrolled hypertension. Particularly among anxious and less conscientious individuals, ambulatory monitoring may improve the tailoring of pharmacological treatments.

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Keywords

Personality; Anxiety; Conscientiousness; Antagonism; Ambulatory Blood Pressure Monitoring; White coat hypertension; Pseudo-resistant hypertension due to white coat effect; Masked hypertension; Masked uncontrolled hypertension; Antihypertensive medications

Introduction

Psychological mechanisms are thought to play an important role in both white coat and masked hypertension [1]. The white coat effect refers to elevated blood pressure (BP) in a clinical setting that is not confirmed by home or ambulatory BP measurement (ABPM). The masked (or hidden) phenomenon refers to normal BP in a clinic setting but elevated BP outside of the clinic [2]. These masked and white coat effects are relatively frequent causes of misdiagnosed hypertension, which can lead to over- and under-medication and elevated cardiovascular risks [3–6].

Anxiety is thought to increase BP in clinical settings. For example, in a study of 238 hypertensive patients, those with white coat hypertension experienced significantly higher levels of anxiety during BP measurement in the clinic [7]. Anxiety and other forms of psychological distress, however, may have greater effects among those taking antihypertensive medications or who are otherwise aware of their hypertensive status [8, 9]. Apart from anxiety, studies of anger [10], depression [11–13], and other neuroticism-related constructs [14, 15] have found inconsistent evidence for associations with the white coat effect. There has been comparatively less research on the role of other personality dispositions. Among the few exceptions is a Japanese study that compared clinical screenings to home BP measurements in 666 individuals [15]. They found no associations with neuroticism, but introverted participants had a larger difference between the screening and the home systolic BPs.

Even less is known about the personality correlates of the masked hypertension phenomenon. A recent study suggests that those with masked hypertension scored lower on a measure of depressed mood and type-A personality compared to white coat and sustained hypertension groups [11]. Other studies have found that masked hypertension is associated with hypochondria and depression [16], but not anxiety [7].

Although there is no consistent evidence that an individual’s personality contributes to the misdiagnosis of hypertension, most studies have been based on relatively small sample sizes that were only powered to detect large effects. Furthermore, previous studies have focused on anxiety and psychological distress. To our knowledge, no study to date has examined the full spectrum of the five factor-model of personality, the consensus framework for much of contemporary personality psychology [17, 18]. In a large community-based sample, we investigated whether anxiety and the five major dimensions of personality can help identify individuals more likely to present masked and white coat effects. We further tested the moderating role of age, sex, and antihypertensive medications.

Method

Sample

The sample was drawn from the SardiNIA project, a multidisciplinary longitudinal study of aging-related traits [19]. Participants were recruited from a rural community from the island of Sardinia (Italy). All residents aged 14 years and older in four towns were invited to participate in the study; at baseline (2001–2004), we recruited over 62% of the eligible population [19, 20]. The sample was not selected based on blood pressure parameters or psychological profile. Personality traits were assessed at the baseline visit, while the ABPM and clinic BP were assessed an average of 7.34 years later (SD=0.87). At baseline, 6162 individuals agreed to enroll in the study. As described in details elsewhere [20], 230 participants were unable or refused to complete the personality questionnaire and 263 of the protocols were deemed invalid according to standard criteria described in the test Manual [18]. Therefore, we had personality data from 5669 participants at baseline [20]. We began the 24-hour ABPM at the third wave of assessment. At the time we conducted the analyses for this study, we had 24-hour ABPM data from 3800 participants, but 483 had no valid personality data and 469 were not included in the analyses based on the ABPM exclusion criteria described below. The final analytic sample included a total of 2,848 participants who had both personality scores and BP measurements (ABPM and clinic BP). The study protocol and the consent form were approved by Institutional Review Boards in Italy and the USA. All participants signed an informed consent before participation in the study.

Measures - Personality Assessment

Participants completed the Italian version of the Revised NEO Personality Inventory (NEO-PI-R)[18, 21]. The NEO-PI-R is a widely used measure of the five major dimensions of personality, known as neuroticism: the tendency to experience emotional distress, anxiety, and depression; extraversion: sociable, out-going, full of energy and with a positive outlook; openness: creative, unconventional, curious, and sensitive to feelings and aesthetics; agreeableness: a tendency to trust, cooperate, and please others; and conscientiousness: a measure of self-discipline, order, diligence, and industriousness. In addition to these broad domains, the 240-item NEO-PI-R assesses 30 facets, six for each of the five major dimensions of personality. In this study we focus on anxiety (one of the facets of neuroticism) and the five major factors [18].

Participants filled out the self-report questionnaire (90%) or chose to have the questionnaire read by a trained Sardinian psychologist (10%). A variable (test administration) that indicated this difference in the administration of the NEO-PI-R was used as a covariate in the analyses. Raw scores were standardized as T scores (M = 5, SD = 1) using combined-sex norms reported in the inventory's manual [18]. The NEO-PI-R scales have robust psychometric properties [22]. In this sample, the NEO-PI-R factor structure shows good congruence with the normative structure and the internal consistencies for the five dimensions ranged from .80 to .87. Individual differences in personality traits are generally consistent across measurement occasions. Indeed, for the NEO-PI-R trait anxiety the test-retest correlation was .71 between two assessments, on average 10 years apart (range 6 to 15 years)[23]. For the five major dimensions assessed by the NEO-PI-R, the test-retest

correlations have been found to range from .78 to .85 over an average interval of 10 years [23].

Measures – clinic and ABPM

The clinic BP assessments were taken by a nurse using a mercury sphygmomanometer and an appropriately sized cuff. Measurements were taken with the subjects in the seated position with the arm at the level of the heart, following a 5-minute quiet resting period. Three consecutive assessments of BP were taken and the mean of the second and third were used for analyses. Medication usage (including beta-blockers, angiotensin-converting enzyme inhibitors, diuretics, nitrates, and calcium channel blockers) and cigarette smoking were recorded, and weight and height were measured by the clinic staff to calculate body mass index (BMI, Kg/m^2).

The SardiNIA project protocol included the ABPM starting with the third wave of assessment [24]. A SpaceLabs 90207 (SpaceLabs Redmond, WA) device was used to monitor ambulatory BP over 24 hours. A cuff of appropriate size was placed on the left arm. BP measurements were taken at 20-minute intervals from 6:00AM to 10:00PM and at 40-minute intervals during the nighttime. Only individuals with more than 30 valid BP readings during the daytime and 9 or more during nighttime were included in the analyses.

Diagnostic group criteria

There are several criteria to classify hypertension status based on daytime or 24-hour ABPMs. In this study, we followed the guideline from the European Society of Hypertension position paper [25]. Table 1 presents the thresholds used to define 8 groups based on antihypertensive medications and systolic/diastolic BP from the clinic and the 24-hour ABPM.

Statistical analyses

Logistic regressions were used to examine whether each personality trait was associated with a higher risk of white coat effect or masked phenomenon when compared to the group with BP in the normal range. Covariates were entered in a first step and the personality trait in a second step. Interactions of each trait with antihypertensive medication, sex or age were tested in additional logistic models that included the interaction term in a third step. The analyses controlled for age, sex, education, antihypertensive medications, season (BP tends to be lower in the summer, 21-June to 21-September), time interval, cigarette smoking, BMI, and personality test administration. We repeated the analyses by further adjusting for use of benzodiazepines and antidepressant medications. The p-values are reported without correction for multiple testing to avoid inflated type 2 errors. The analyses were run using SPSS software version 20 (IBM SPSS Statistics).

Results

Table 2 provides the numbers of individuals and the demographic characteristics for each diagnostic group. A total of 554 individuals reported taking antihypertensive medications. The white coat effect was observed in 229 individuals and masked hypertension or masked

uncontrolled hypertension was observed in 443 individuals. Overall, the rate of white coat and masked hypertension found in this sample is roughly similar to what has been reported in other studies [3, 16, 26]. Compared to the normotensive, the other groups were generally older, more likely to be male, and less educated. The BMI and percent obese were considerably higher among the hypertensive and white coat hypertensive.

Logistic regressions were used to examine the association between personality traits and the white coat effect (Table 3). Anxiety and the five personality factors were not associated with the white coat effect in the whole sample. However, we found a significant interaction between anxiety and antihypertensive medications use in predicting the white coat effect ($p = 0.0005$). In the group treated with antihypertensive medication, scoring 1 SD higher on anxiety was associated with a 39% higher risk of pseudo-resistant hypertension due to white coat effect (OR = 1.39, 95%CI = 1.01–1.91). Among participants not taking antihypertensive medications, anxiety was not associated with white coat hypertension (OR = 0.81, 95%CI = 0.64–1.03).

Similar logistic regression analyses indicated that anxiety and the five personality factors were not associated with the masked hypertension phenomenon. There was a significant interaction between conscientiousness and antihypertensive medications use ($p = 0.03$). Among those taking antihypertensive medications, higher conscientiousness was associated with a lower risk of masked uncontrolled hypertension (OR = 0.70, 95%CI = 0.49–0.99). There was no association in the rest of the sample (OR = 1.05, 95%CI = 0.92–1.19).

We further examined whether the association between personality and the white coat and masked phenomena differed between males and females, or whether it varied with age. None of the interaction terms was significant. We repeated the analyses with benzodiazepine and antidepressant medications as additional covariates and the results remained the same. We further examined whether the neuroticism factor interacted with the other major factors of personality in predicting white coat and masked hypertension, but no significant interactions were found. Finally, we tested the robustness of the results by repeating the analyses using different thresholds of ABPM. For example, using the daytime threshold of 135/85 we again found that anxiety was associated with risk of pseudo-resistant hypertension due to white coat effect and that conscientiousness was associated with masked uncontrolled hypertension ($p < .05$).

Discussion

In a long-term prospective study we examined whether anxiety and other personality traits predicted masked and white coat effects. Results indicated that antihypertensive medication use was an important moderator: Among those taking antihypertensive drugs, participants with higher anxiety were more likely to present pseudo-resistant hypertension due to white coat effect and less conscientious participants were at higher risk of masked uncontrolled hypertension. These associations were found only among those taking antihypertensive drugs; anxiety and other personality traits were unrelated to the masked and white coat effects among healthy and untreated individuals.

The interaction we observed between anxiety and medication is consistent with other evidence of labeling or drug effects in hypertension. A study of 214 normotensive and mildly hypertensive individuals [9] found that those who perceived themselves as hypertensive had a larger white coat effect and were more anxious while assessed at the clinic. Although ambulatory BP was not assessed, a UK study of 33,105 adults [8] found elevated psychological distress among hypertensive individuals who were on antihypertensive medications or otherwise aware of their hypertensive status, and a weak effect in the opposite direction among those unaware of their hypertension. Furthermore, a multinational survey found that individuals with treatment-resistant hypertension reported greater stress, worse health, and more concerns over their elevated BP than individuals with uncontrolled hypertension [27]. The present study extends these previous findings by indicating that among those treated with antihypertensive medications, a tendency to be anxious is a long term predictor of pseudo-resistant hypertension due to white coat effect. For these anxious individuals, the clinical assessment may raise the stressful prospect that despite being on medications, they may still have high BP.

The finding that higher anxiety is not associated with increased risk of white coat effect among the untreated group is somewhat surprising. Higher anxiety is thought to provoke a greater BP surge during the clinic assessment, but our data suggest that the heightened reactivity is only present among the treated hypertensive. The clinic BP assessment does not seem to worry or stress anxious individuals who are untreated. The clinic visit may actually reduce the worries of anxious and hypochondriac individuals.

This study found no evidence that a general proneness to negative emotions (neuroticism) is associated with the masked hypertension phenomenon. Given the mixed evidence from previous studies [7, 11, 16], it is unlikely that there are large main effects of neuroticism or anxiety on masked hypertension. The moderation analyses suggest that among those taking antihypertensive medications, lower conscientiousness predicted higher risk of masked uncontrolled hypertension. This association may derive from differences in adherence to pharmacological treatment. That is, less diligent patients tend to have worse adherence to antihypertensive treatment than more conscientious ones [28, 29], and ABPM is more sensitive than the clinic assessment in detecting poorly-controlled BP. More broadly, this finding is consistent with other evidence that low conscientiousness is associated with risk factors for hypertension such as obesity [30], physical inactivity [31, 32], and tobacco smoking [33]. In this and many other samples, conscientiousness has been related to cardiovascular [34], metabolic [35], and inflammatory [36] markers, as well as medical conditions [37, 38], treatment adherence [28, 29], and premature mortality [39–42].

This study has a number of limitations that need to be considered when evaluating the results. The sample included in the analyses was not representative of the targeted population, and a considerable number of participants were lost to follow-up. However, this study is one of the largest to date that examined the links between psychological traits and 24-hour blood pressure parameters in a non-clinical population. Given the demanding nature of wearing a blood pressure monitor for a 24-hour period (especially for working adults), it is remarkable that about 3,000 generally healthy adults agreed to take part in the ABPM assessment. It is also important to note that although we controlled for important covariates,

other factors may have influenced the results. Furthermore, it would have been ideal to have ABPM at both baseline and follow-up. ABPM at two or more assessment points would provide data for more reliable classification of the groups and the possibility to track BP and personality parameters over time.

This study has clinical implications. Although there is a mixed literature on the association of psychological traits and hypertension [8, 43–45], higher anxiety is associated with an increased risk of pseudo-resistant hypertension due to white coat effect among those on antihypertensive medications. These patients may present with elevated BP at the clinic, which may reflect their heightened anxiety and in particular a concern about the clinical assessment [9]. The white coat effect can lead to excessive pharmacological intervention, which would not be called for if ABPM is used. Anxious patients on antihypertensive medications could benefit the most from ambulatory monitoring, as they are the most vulnerable to the white coat effect. It may also be beneficial to test ABPM on those low in conscientiousness, because we found them to be more likely to have masked uncontrolled hypertension and tending to present other risk factors for hypertension.

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Table 1

Categories based on the joint assessment of clinic and ambulatory blood pressure (BP).

Antihypertensive drugs	**Categories**			
No	**Normotension**	**Hypertension**	**White Coat Hypertension**	**Masked Hypertension**
	Clinic <140/90 ABPM <130/80	Clinic ≥140/90 ABPM ≥130/80	Clinic ≥140/90 ABPM <130/80	Clinic <140/90 ABPM ≥130/80
Yes	**Controlled Hypertension**	**Resistant Hypertension**	**Pseudo- Resistant hypertension due to white coat effect**	**Masked uncontrolled hypertension**
	Clinic <140/90 ABPM <130/80	Clinic ≥140/90 ABPM ≥130/80	Clinic ≥140/90 ABPM <130/80	Clinic <140/90 ABPM ≥130/80

Notes: ABPM = Ambulatory Blood Pressure Monitoring. ABPM are based on 24-h recording. Numeric values refer to systolic/diastolic mmHg blood pressure. See European Society of Hypertension guidelines for more information on the labels and thresholds that define each category [25].

Table 2

Characteristics of the diagnostic groups

	Normotension	**Hypertension**	**White Coat Hypertension**	**Masked Hypertension**
N	1582	219	128	355
Age,	44.26 (13.47)	57.21 (11.66)	58.20 (12.88)	48.26 (13.18)
Female, N (%)	1096 (69.3%)	74 (33.8%)	59 (46.1%)	187 (52.7%)
Education	3.44 (0.87)	2.98 (0.91)	2.89 (0.83)	3.29 (0.80)
BMI	24.42 (4.03)	28.38 (4.17)	28.80 (4.29)	25.52 (4.01)
Obesity, N	146 (9.2%)	62 (28.3%)	41 (32.0%)	46 (13.0%)
Ever Smoker, N	628 (39.7%)	106 (48.4%)	47 (36.7%)	172 (48.5%)
	Controlled Hypertension	**Resistant hypertension**	**Pseudo- Resistant hypertension due to white coat effect**	**Masked uncontrolled hypertension**
N	229	136	101	88
Age,	65.18 (10.57)	67.46 (10.38)	66.17 (9.05)	63.86 (10.71)
Female, N (%)	139 (60.7%)	56 (41.2%)	68 (67.3%)	34 (38.6%)
Education	2.68 (0.91)	2.54 (0.89)	2.52 (0.88)	2.75 (0.89)
BMI	28.80 (4.09)	29.49 (4.67)	30.48 (5.94)	27.24 (3.55)
Obesity, N	82 (35.8%)	63 (46.3%)	44 (43.6%)	24 (27.3%)
Ever Smoker, N	72 (31.4%)	54 (39.7%)	33 (32.7%)	41 (46.6%)

Note: BMI is body mass index (Kg/m^2). Education is on a scale from 1 (no education) to 5 (university degree).

Table 3

Association between personality traits, white coat and masked hypertension phenomena in the full sample and those who did or did not report taking antihypertensive medications.

Variable	Total OR (95%CI)	No medication OR (95%CI)	Medication OR (95%CI)
	White Coat Effect 229/1811	**White Coat Hypertension** 128/1582	**Pseudo- Resistant hypertension due to white coat effect** 101/229
N1: Anxiety	0.96 (0.80–1.15)	0.81 (0.64–1.03)	1.39 (1.01–1.91)*
N: Neuroticism	0.86 (0.71–1.04)	0.81 (0.63–1.03)	1.02 (0.75–1.41)
E: Extraversion	0.96 (0.79–1.16)	0.91 (0.71–1.17)	1.02 (0.76–1.39)
O: Openness	0.92 (0.77–1.12)	0.81 (0.63–1.04)	1.11 (0.82–1.50)
A: Agreeableness	1.11 (0.92–1.33)	1.03 (0.82–1.30)	1.26 (0.93–1.72)
C: Conscientiousness	1.04 (0.86–1.25)	1.04 (0.83–1.31)	1.01 (0.74–1.40)
cases/N	**Masked phenomenon** 443/1811	**Masked Hypertension** 355/1582	**Masked Uncontrolled Hypertension** 88/229
N1: Anxiety	1.08 (0.95–1.22)	1.07 (0.93–1.22)	1.02 (0.72–1.43)
N: Neuroticism	1.00 (0.88–1.14)	1.03 (0.90–1.18)	0.82 (0.58–1.15)
E: Extraversion	0.93 (0.82–1.06)	0.94 (0.82–1.08)	0.94 (0.68–1.29)
O: Openness	0.99 (0.87–1.11)	1.00 (0.88–1.15)	0.89 (0.64–1.23)
A: Agreeableness	1.09 (0.96–1.23)	1.14 (0.99–1.30)	0.84 (0.60–1.17)
C: Conscientiousness	1.00 (0.89–1.13)	1.05 (0.92–1.19)	0.70 (0.49–0.99)*

Notes. OR (95%CI) = Odds ratio (95% Confidence Interval) from logistic regressions adjusted for age, sex, education, antihypertensive medications (in the total sample), season, time interval, cigarette smoking, BMI, and personality test administration. Medication refers to antihypertensive. The Ns refer to the total sample in the analyses, which compared individuals with BP in the normal range to cases (white coat or masked phenomena groups).

* $p < 0.05$.