

Working Conditions and Masked Hypertension

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Abstract

Introduction Masked hypertension, i.e., normal clinic blood pressure but elevated blood pressure during normal daily activities as measured by ambulatory monitoring, is a common problem and a serious cardiovascular risk factor. Given previously reported associations between work stressors and ambulatory blood pressure, an inquiry into the relationship between work stressors and masked hypertension is warranted.

Objective To assess the relationship between working conditions and masked hypertension.

Design Cross-sectional study.

Setting Hospital and home care employers in New York City.

Study Participants Forty-five male and 119 female hospital and home care employee volunteers wore an ambulatory blood pressure monitor during working hours.

Main Outcome Measures Masked hypertension was defined as work systolic ambulatory blood pressure ≥ 135 mmHg or diastolic ambulatory blood pressure ≥ 85 mmHg, and casual blood pressure $< 140/90$ mmHg

with no use of antihypertensive medications. Associations between work stressors and masked hypertension were tested by multiple logistic regression.

Results Masked hypertension, observed in 24.0 % of males and 17.6 % of females with normal casual office obtained blood pressure, was associated with evening, night or rotating shiftwork (odds ratio (OR) 8.25, 95 % confidence interval (CI) 2.11–40.31) and with the combination of job strain and effort-reward imbalance (OR 2.97, 95 % CI 1.02–8.60) after controlling for age. Associations remained substantial, and statistically significant for shiftwork, after individual adjustment for each of 10 potential confounders. Masked hypertension was not associated with total weekly work hours.

Conclusions Masked hypertension is a significant individual and public health concern. Additional research is needed to clarify the role of work-related risk factors in the development of masked hypertension, and to develop an appropriate clinical and public health strategy for diagnosis, treatment and prevention.

Keywords Job stress · Job strain · Effort-reward imbalance · Shiftwork · Work hours · Masked hypertension · Ambulatory blood pressure

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1 Introduction

Ambulatory blood pressure monitoring (ABPM) allows for the identification of masked hypertension (MH), also referred to as “occult” hypertension [1, 2]. It is characterized by elevated ambulatory blood pressure (ABP) during daily activities, such as work, but normal BP when measured in a clinician’s office. In general population studies, the prevalence of MH among people with normal

clinic obtained BP ranges from 10 to 30 % [3–6]. People with MH often demonstrate target organ damage, such as increased left ventricular mass [4–8] increased carotid plaque burden [7, 9], and increased risk of developing cardiovascular disease (CVD) [4, 5, 10–12] at rates and severity similar to patients with a diagnosis of hypertension.

To date there have been five published studies that have examined work-related risk factors for MH. Gallo et al. found that MH (based on elevated 48-h systolic ABP on workdays) was more common in blue collar and clerical female workers than among higher status white-collar female workers, though this relationship was not observed for diastolic ABP [13]. Yamasue et al. found that male managerial employees had significantly higher awake ABP (and MH, personal communication, K. Yamasue) than that of retirees of similar age [14]. Belkic et al. examined the psychosocial work stressor “job strain” (high job demands combined with low job control), using a slightly different definition of MH (≥ 85 mmHg diastolic work ABP), and found an association between job strain and MH among men in the Cornell Work Site BP Study, conducted in New York City, however, the association did not reach statistical significance (prevalence ratio 1.55) [1, 2]. Konstantopoulou et al. found that “high work responsibilities” were more prevalent in patients with masked hypertension than those with white-coat hypertension [15]. In a population of white-collar workers, Trudel et al. [16] found that MH was associated with both higher job demands and *higher* job control among men (thus no association with “job strain”), and no significant associations with job strain were observed for women.

A recent meta-analysis of 22 studies of job strain indicates a significant positive association with systolic (3.4 mmHg) and diastolic (2.1 mmHg) ABP [17]. Some studies have also reported associations between BP elevation and long work hours [18, 19], high work efforts combined with low rewards [20, 21] and “threat-avoidant vigilance” [22, 23] while there is less evidence for a role for shift work [24–26]. Therefore, we hypothesized that job strain, effort-reward imbalance, the combination of job strain and effort-reward imbalance, shiftwork and long work hours would be associated with masked hypertension.

2 Methods

2.1 Subjects

Participants were volunteers for a study of working conditions and ambulatory blood pressure recruited from employees at a hospital and from home health care agencies in New York City between September 2004 and

September 2005. Individuals were eligible for the study if they were working full-time at the hospital or as a home health aide for at least one year and were at least 18 years of age. Participants completed a questionnaire, then wore an ABP monitor throughout a work-shift, and were compensated \$25 for participation. While participants were encouraged to wear the monitor for 24 h, they were only required to wear the monitor during work hours. Ten home health care workers and 175 hospital workers wore an ABP monitor on a work shift. The median time between return of the completed survey and ABP monitor placement was 28 days (range 0–147 days). All participants were still employed at the same site when the questionnaires were returned. All research procedures were approved by the hospital’s Institutional Review Board, and all participants provided informed consent.

2.2 Procedures

On the day of the scheduled ABPM, hospital workers met with a trained technician either at the study office (near the hospital) or at the participant’s work location in the hospital. Home care workers met the technician either at their agency or the technician traveled to the worker’s home to place the monitor. Prior to the start of their work shift, participants had their BP measured in a seated position with their arm supported at the level of their heart. Three measurements with the Spacelabs 90207 or 90217 ABPM were done simultaneously with an upper arm aneroid sphygmomanometer; a Y-connector facilitated the simultaneous measurements. Cuff size was determined by upper arm circumference. For ABPM readings to be considered acceptable for utilization in the study, the average of the three readings was required to be within ± 10 mmHg of the systolic BP [27] heard on sphygmomanometry. The Spacelabs monitor calibration readings served as the clinic or “casual” BP readings for the study.

The ABP monitor was programmed to take BP readings automatically every 30 min. Participants were asked to complete a short diary in which they recorded the time of the reading, their location (work or home), and their position (standing, sitting, or lying down). This information was used to calculate averages for both systolic and diastolic ABP by location. Participants returned the monitor and diary to the study office after their shift or the next day.

2.3 Psychosocial Questionnaire

Before BP measurement, participants completed Karasek’s Job Content Questionnaire, assessing psychological job demands and job decision latitude [28, 29] and Siegrist’s Effort-Reward Imbalance questionnaire [30]. Physical job demands was measured by a single item (job requires lots

of physical effort). In the previously conducted Work Site BP Study, the 3-year test–retest reliability for both job decision latitude and for psychological job demands was $r = 0.64$ [31] and for physical job demands was $r = 0.67$ [32]. Other information obtained by self-report questionnaire included hours worked per week on main health care job and on second job (if any), shift schedule, hours worked per week on tasks at home, and demographics.

Biomedical and behavioral questions derived from the Work Site BP Study questionnaire [31, 33] included hours per week of leisure time physical exertion, height, and weight. Yes/no questions were included for current pregnancy, current or past diabetes, current use of antihypertensive medications, ever diagnosed with hypertension, and family history of hypertension. Body mass index was computed as $\text{weight (kg)/height (m)}^2$. Alcohol consumption was measured as the sum of the number of glasses of wine, bottles or cans of beer (12 oz.), and mixed drinks (1 shot of liquor) consumed per week [34]. Current smoking was based on one question (“do you smoke cigarettes?” (yes/no)), which had a 3-year test–retest reliability of 0.69 (κ) in the Work Site BP Study [32].

2.4 Data Analysis

Job strain was modeled using the standard definition of high psychological job demands combined with low job decision latitude [33]. National averages for all employees from the 1969–1977 US. Quality of Employment Surveys were used as reference points [29]. Job strain based on these cutpoints was defined as job demands >30.9 and decision latitude <70.3 .

Effort-reward imbalance was calculated using the formulas of Siegrist and Peter [30]. The sum of the six effort items equaled E and the sum of the 11 reward items equaled R. The formula $E/(R*6/11)$ produces a ratio score, which equally weights efforts and rewards. Higher values represent higher levels of job stress, that is, greater effort combined with lower reward. This ratio was dichotomized so that “effort-reward imbalance” is defined as $E/(R*6/11) > 1$. A dichotomous variable “job strain and effort-reward imbalance” was created, defined as “yes” if participants reported both job strain and effort-reward imbalance, to determine the risk of combined exposure.

Work hours Number of hours usually worked per week on the participant’s health care job and on a second paid job (if any) were summed into a measure of “total paid hours worked per week”. This work hour measure was summed with hours worked per week on tasks at home to create a measure of “total paid plus home hours worked per week”.

Shiftwork Since more than 85 % of the sample worked regular day shifts, for the purposes of data analysis,

participants reporting work on evening or night shifts, or rotating shifts, were classified as having “shiftwork”.

Work systolic and diastolic ABP was determined by averaging ABPM readings obtained during work hours (as per diary record). If fewer than 5 readings were obtained at work, the average was treated as missing data. Five readings are considered minimally sufficient to produce reliable estimates of mean work BP [35]. Five or more work readings were obtained from 175 ABP participants. The average number of valid work readings was 15.8 ± 6.5 . Casual BP readings were available for 164 participants who wore the ABP monitor and had at least 5 ABPM work readings. Only 22 participants had 5 or more home readings, thus home ABP averages were not analyzed. MH was defined according to the recommendations of the European Society of Hypertension Working Group [36] and the American Heart Association [37] as awake systolic ABP ≥ 135 mmHg or diastolic ABP ≥ 85 mmHg combined with casual office obtained systolic BP <140 mmHg and diastolic BP <90 mmHg. 21 subjects met these criteria. Since we were interested in risk factors for MH in the general population and not among treated hypertensive patients, we added as a criterion for MH that there be no use of antihypertensive medications among participants.

After excluding those participants with office obtained casual blood pressure above 140/90 mmHg, associations between each work stressor and MH were examined by multiple logistic regression. Since a minimum of 10 cases per predictor variable is recommended to avoid overfitting regression models [38], and since only 21 cases were included in the analysis, only odds ratios controlling for age are presented. However, in exploratory analyses, in order to assess additional confounding, each of 10 potential confounders (gender, race (black vs. other), physical job demands, leisure time exercise, body mass index, pregnancy, alcoholic drinks/week, smoking, family history of hypertension and ever diagnosed with hypertension) were added in separate regression models to the model containing the work stressor and age. Regression analyses, controlling for age, were also conducted excluding participants reporting that they were pregnant or had ever been diagnosed with hypertension. Analyses were conducted using SPSS v. 16.0.2.

3 Results

3.1 Study Sample

The study sample consisted of 164 health care workers with complete BP and survey data, 72.6 % of whom were female; average age 44.8 years (range 23–76); 48.8 % were African-American; and 23.2 % reported their highest

educational level as high school. The most frequent job category was clerical (42.7 %). Less than one-half were involved in direct patient care in job titles such as registered nurse (4.3 %), licensed practical nurse and certified nurse assistant (17.1 %), social worker, physicians' assistant or emergency medical technician (4.3 %), operating room, laboratory, radiology, ultrasound, tomography, other technicians and technologists; rehabilitation, physical, occupation, recreational and speech pathologists or therapists (15.2 %) and home health care worker (5.5 %). Evening, night or rotating shifts were worked by 12.7 % of the sample.

3.2 Masked Hypertension

Of the 164 participants, 30 had office based casual systolic BP ≥ 140 mmHg or diastolic BP ≥ 90 mmHg (two of the 30 had "white coat" hypertension and 28 had sustained hypertension). Twenty four additional participants were taking anti-hypertensive medications. After excluding these 54 subjects, 110 participants remained for analysis. Of these, 21 had work ABP averages above the threshold and therefore were defined as having MH (24.0 % of men and 17.6 % of women). In bivariate analyses, there were only two significant differences between participants with MH and those with normal casual BP and ABP below the threshold (and not on hypertensive medication) (see Table 1) Those with MH were significantly more likely to report working evening, night or rotating shiftwork ($p = 0.002$) and to be older ($p = 0.02$).

In multivariate analyses, controlling for age, MH was still significantly associated with evening, night or rotating shiftwork (odds ratio (OR) 8.25, 95 % confidence interval (CI) 2.11–40.31) and also with the combination of job strain and effort-reward imbalance (OR 2.97, 95 % CI 1.02–8.60) (Table 2). In no cases did adjustment for each of 10 additional covariates reduce the odds ratios for shiftwork or for job strain plus effort-reward imbalance more than 10 % (In approximately half the cases, adjustment increased the odds ratios.). The association with shiftwork remained significant and substantial in all cases, however, the odds ratio for job strain plus effort-reward imbalance was 2.69 (95 % CI 0.86–8.43), which was of borderline significance ($p = 0.09$) after controlling for physical job demands. Work hours were not associated with MH.

When pregnant women or those previously diagnosed with hypertension were excluded, the association between MH and shiftwork remained substantial and significant. The association for job strain plus effort-reward imbalance increased, but was of borderline statistical significance ($p = 0.051$). Similar results were obtained if the sample was restricted to hospital workers, or if sample median

cutpoints for job demands and job decision latitude were used to define job strain. Stronger associations with job strain and effort-reward imbalance, but weaker although significant associations with shiftwork, were obtained if the sample was restricted to women (data not shown).

4 Discussion

The current study suggests that workers exposed to shiftwork and a combination of job strain plus effort-reward imbalance are at increased risk for MH. These findings are consistent with and complement prior studies which have shown associations between ABP and job strain [17, 22, 31, 39, 40] and ABP and effort-reward imbalance [20, 21]. However, limited evidence previously existed for an association between ABP elevation and shift work [24–26]. Our findings may help to explain the previously reported associations between job strain and CVD [41, 42] since both BP elevation and MH are risk factors for cardiovascular disease (CVD) [10–12].

In our study, the majority of participants were in lower status occupations. Several studies have provided evidence of a stronger association between job strain and BP elevation in lower (vs. higher) socioeconomic groups [13, 43, 44]. The largest study of job strain and MH to date [16] was conducted in a high status white-collar population, and found an association between MH and high job demands and *high* job control (but not job strain), in contrast to the findings of the current study. More research is needed on whether the association of job strain (and other work stressors) and ABP and MH differs by socioeconomic status.

The prevalence of MH in the current study among participants with normal clinic BP was similar to that of other studies of healthy subjects, i.e., not hypertensive patients [3]. However, since the current study sample was comprised of volunteers, and therefore subject to potential selection bias, the observed prevalence of MH may not reflect the prevalence of MH among the employees of the hospital or the home health care agencies where study volunteers worked.

One limitation of the current study is that long work hours were not common in the study sample. Only 8.2 % of the participants typically worked 50 or more hours per week. Hayashi et al. [18] found an effect of long work hours on ABP in employees working at least 55 h per week or more. Another limitation is that most casual BP measurements were taken at the work site; therefore they are casual but not truly "clinic" BP. It is possible that if true clinic BP measurements were used (i.e., not in the participants' work environment) levels of casual BP might have been lower, and the prevalence of MH in the current study might have been higher [1, 2]. Since job strain would likely

Table 1 Comparison of participants with masked hypertension to those with normal work blood pressure (among participants with normal casual blood pressure, <140/90 mmHg, and not on medication for hypertension)

| | Normal work ABP: Work ambulatory SBP <135 and DBP <85 mmHg | | Masked hypertension: Work ambulatory SBP ≥135 or DBP ≥85 mmHg | | χ^2 | p | |
|---|--|-------------|---|-------------|-----------|----------|----------|
| | N | % | N | % | | | |
| Total | 89 | 100 | 21 | 100 | | | |
| Female gender | 70 | 78.7 | 15 | 71.4 | 0.51 | 0.48 | |
| Race/Ethnicity: | | | | | 7.42 | 0.12 | |
| Black | 43 | 48.3 | 9 | 42.9 | | | |
| White | 14 | 15.7 | 3 | 14.3 | | | |
| Hispanic | 29 | 32.6 | 5 | 23.8 | | | |
| Asian | 1 | 1.1 | 2 | 9.5 | | | |
| Other | 2 | 2.2 | 2 | 9.5 | | | |
| Education: | | | | | 1.73 | 0.79 | |
| Some high school | 3 | 3.4 | 1 | 4.8 | | | |
| High school diploma | 14 | 15.7 | 5 | 23.8 | | | |
| Some college | 46 | 51.7 | 10 | 47.6 | | | |
| 4-year college degree | 15 | 16.9 | 4 | 19.0 | | | |
| Graduate school | 11 | 12.4 | 1 | 4.8 | | | |
| Current smoker | 15 | 16.9 | 2 | 9.5 | 0.70 | 0.40 | |
| Family history of hypertension | 48 | 53.9 | 10 | 47.6 | 0.27 | 0.60 | |
| Diabetes | 0 | 0 | 0 | 0 | – | – | |
| Pregnancy | 6 | 6.7 | 3 | 14.3 | 1.29 | 0.26 | |
| Leisure-time exercise hours/week | | | | | 1.59 | .66 | |
| <1 h | 38 | 42.7 | 12 | 57.1 | | | |
| 1–3 h | 26 | 29.2 | 5 | 23.8 | | | |
| 4–6 h | 15 | 16.9 | 2 | 9.5 | | | |
| >6 h | 10 | 11.2 | 2 | 9.5 | | | |
| Evening, night or rotating shift | 7 | 7.9 | 7 | 33.3 | 9.92 | 0.002 | |
| Job strain | 46 | 51.7 | 13 | 61.9 | 0.71 | 0.40 | |
| Effort-reward imbalance >1 | 42 | 47.2 | 12 | 57.1 | 0.67 | 0.41 | |
| Job strain and effort-reward imbalance >1 | 32 | 36.0 | 11 | 52.4 | 1.93 | 0.17 | |
| | | Mean | SD | Mean | SD | t | p |
| Mean casual BP: systolic | | 115.0 | 10.3 | 128.9 | 9.9 | 10.65 | <0.001 |
| Diastolic | | 70.7 | 7.2 | 81.3 | 5.6 | 9.51 | <0.001 |
| Mean work ambulatory BP: systolic | | 114.9 | 8.9 | 134.7 | 7.2 | 6.33 | <0.001 |
| Diastolic | | 74.0 | 6.9 | 85.9 | 3.9 | 5.59 | <0.001 |
| Age | | 40.8 | 11.11 | 47.4 | 12.84 | 2.37 | 0.02 |
| Body mass index | | 27.7 | 5.43 | 26.9 | 3.74 | 0.60 | 0.55 |
| Physical job demands | | 2.47 | 0.96 | 2.71 | 0.72 | 1.30 | 0.20 |
| Alcohol use (drinks per week) | | 0.97 | 1.46 | 1.48 | 2.11 | 1.05 | 0.30 |
| Paid hours worked per week | | 40.4 | 6.63 | 40.0 | 6.60 | 0.28 | 0.78 |
| Total hours worked per week (paid plus home hours) | | 52.4 | 15.36 | 49.0 | 10.21 | 0.96 | 0.34 |

n = 110 participants with casual blood pressure <140/90 mmHg, and not on medication for hypertension

be associated with larger differences between casual clinic BP and casual workplace BP, use of casual workplace BP in the current study biases results towards the null value. In addition, casual BP readings should be taken on several

occasions to reduce error in classifying individuals as clinically normotensive or hypertensive. The direction of bias caused by such measurement errors in the current study is unknown.

Table 2 Work-related predictors of masked hypertension, adjusted for age

| | Odds ratio | 95 % Confidence interval | p |
|--|------------|--------------------------|-------|
| Job strain | 1.82 | 0.66–5.05 | 0.25 |
| Effort/reward imbalance >1 | 2.05 | 0.73–5.74 | 0.17 |
| Job strain + effort/reward imbalance >1 | 2.97 | 1.02–8.60 | 0.045 |
| Evening, night, rotating shiftwork | 8.25 | 2.11–40.31 | 0.002 |
| ≥41 h worked per week | 0.86 | 0.25–2.94 | 0.81 |
| ≥57.5 paid plus home hours worked per week (20th percentile) | 1.33 | 0.45–3.96 | 0.61 |

n = 110 participants with casual blood pressure <140/90 mmHg, and not on medication for hypertension. A separate regression equation was estimated for each work-related predictor listed

An additional limitation is the small number of participants with MH which prevented simultaneous statistical adjustment for more than 2–3 independent variables. However, none of the potential confounders, when added individually to the regression equation, reduced shiftwork or job strain plus effort reward imbalance odds ratios more than 10 %. Also, limited study power can produce Type II errors when associations do not reach statistical significance. However, in the current study, shiftwork and job strain plus effort-reward imbalance had substantial effects and were significant predictors of MH despite limited statistical power.

Another limitation is that our ABPM data were only available for most participants during work hours. Since only 22 participants had ≥5 home ABP readings, home ABP data were not analyzed. In most studies of MH, the definition of MH is based on mean awake (including work and home) ABP [3]. If awake ABP data had been available for all participants in the current study, the prevalence of MH might have been lower.

Since most published studies do not partition the work and home components of awake ABP, it is unclear to what extent the “at work” component is more responsible than the home component for the prevalence of MH, and its attendant increased target organ damage and CVD risk. One study did find a higher correlation between left ventricular mass and work ABP than home ABP or casual BP [45]. ABP is higher by as much as 4 mmHg systolic during work than non-work time [46, 47] and mean 24-h ABP is lower on non-work days compared to work days [48]. Since work stressors appear to be causally related to work ABP elevation, it is plausible that work stressors are the important risk factors for MH and its sequelae [1, 2] although it is possible that important non-work related risk factors are yet to be discovered. We suggest that data from published studies of MH be re-analyzed and future studies designed to determine whether the work and home components of ABP differentially cause target organ damage or CVD risk. Furthermore, since participants taking antihypertensive medications and those ever diagnosed with

hypertension were excluded from our analyses, it is not known if our findings can be generalized to patients diagnosed with hypertension whose BP appears to be controlled based on casual BP readings but who have elevated ABP (sometimes also labeled “masked hypertension”).

The possibility also exists for self-report to overestimate psychological job demands or job efforts, these being inherently more subjective measures than decision latitude or job rewards. However, participants in the current study did not have ABPM until after they had completed the questionnaire. Did some participants exaggerate their responsibility and authority levels (decision latitude) because of the prevailing popular belief in “executive stress”? If so, then they would have underreported “job strain”, and associations between job strain and MH would have been underestimated. Another potential explanation of the observed associations is that employees with higher ABP or MH selected into jobs with greater job strain, effort-reward imbalance or shiftwork. However, there is little evidence to support either of these hypotheses. In the Work Site BP Study, no association was found between case-control status (or mean ABP) and personality/psychological measures such as anxiety, hostility, anger, or Type A behavior that might influence reporting or job selection [33, 49]. In fact, in national studies [50], as in the Work Site BP Study [32], the opposite pattern is observed—people tend to select out of high stress/strain jobs over time.

5 Conclusions

The current study finds that workers exposed to shiftwork and job strain plus effort-reward imbalance are at increased risk for MH, and suggests that employees in general could benefit from more intensive screening for MH, including targeted ABPM or self-monitoring of BP [3]. Clinicians and workplace health promotion staff should assess job strain, effort-reward imbalance and shiftwork (as well as other work stressors), and prioritize ABP monitoring for

employees facing these work stressors [1–3]. A work exposure and health surveillance program would facilitate appropriate interventions, which may ultimately include job redesign efforts [3].

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