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Research Article

Association of office and ambulatory blood pressure with blood lead in workers before occupational exposure

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Abstract

In view of decreasing lead exposure and guidelines endorsing ambulatory above office blood pressure (BP) measurement, we reassessed association of BP with blood lead (BL) in 236 newly employed men (mean age, 28.6 years) without previous lead exposure not treated for hypertension. Office BP was the mean of five auscultatory readings at one visit. Twenty-four-hour BP was recorded at 15- and 30-minute intervals during wakefulness and sleep. BL was determined by inductively coupled plasma mass spectrometry. Systolic/diastolic office BP averaged 120.0/80.7 mm Hg, and the 24-hour, awake, and asleep BP 125.5/73.6, 129.3/77.9, and 117.6/65.0 mm Hg, respectively. The geometric mean of blood lead was 4.5 μg/dL (interquartile range, 2.60–9.15 μg/dL). In multivariable-adjusted analyses, effect sizes associated with BL doubling were 0.79/0.87 mm Hg ($P = .11/.043$) for office BP and 0.29/−0.25, 0.60/−0.10, and −0.40/−0.43 mm Hg for 24-hour, awake, and asleep BP ($P \geq .33$). Neither office nor 24-hour ambulatory hypertension was related to BL ($P \geq .14$). A clinically relevant white coat effect (WCE; office minus awake BP, ≥20/≥10 mm Hg) was attributable to exceeding the systolic or diastolic threshold in 1 and 45 workers, respectively. With BL doubling, the systolic/diastolic WCE increased by 0.20/0.97 mm Hg ($P = .57/.046$). Accounting for the presence of a diastolic WCE, reduced the association size of office diastolic BP with BL to 0.39 mm Hg (95% confidence interval, −0.20 to 1.33; $P = .15$). In conclusion, a cross-sectional analysis of newly hired workers before lead exposure identified the WCE as confounder of the association between office BP and BL and did not reveal any association between ambulatory BP and BL. J Am Soc Hypertens 2018;12(1):14–24.

Keywords: Hypertension; lead; occupational medicine; white coat hypertension.

W.-Y.Y. and L.E. contributed equally to this article.

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Introduction

Whereas high-level lead exposure leads to hypertension, there is no consensus as to whether low-level lead exposure raises blood pressure (BP) and by this mechanism contributes to cardiovascular complications.[1,2] Lead studies traditionally relied on office BP measurement. Using this approach entails inaccuracy originating in patients, for instance as a consequence of arousal,[3] in the BP measuring device, or in the overall application of the technique.[4] In the auscultatory approach, the observer is the principal source of bias.[4] Ambulatory monitoring substantially refines the precision of BP measurement because of the greater number of readings, the absence of digit preference and observer bias, and the minimization of the white coat effect (WCE).[3,5] Guidelines in North America[6,7] and Europe[5,8] unanimously recommend ambulatory monitoring as the method of choice to record BP.

In the light of falling environmental lead exposure,[9–11] agencies such as the National Toxicology Program[12] and the Environmental Protection Agency[13,14] reviewed the literature in weight-of-the-evidence analyses[15] and suggested that blood lead levels as low as 5 μg/dL might be associated with adverse health effects.[12–15] Along similar lines, in 2010, the American College of Occupational and Environmental Medicine requested that the US Occupational and Health Administration (OSHA) align itself with the scientific evidence, referring in particular to hypertension and cardiovascular disease.[16] However, studies in workers suggest that the toxic effects of lead on the cardiovascular system occur at much higher blood lead levels than in the population, possibly as a consequence of the healthy worker effect.[17] Using the baseline data of the ongoing Study for Promotion of Health in Recycling Lead (SPHERL[18]; NCT02243904), we assessed the association between BP and blood lead, using both office and ambulatory BP measurement, in newly hired workers before occupational lead exposure.

Methods

Study Participants

SPHERL complies with the Helsinki declaration for investigations in human subjects.[19] All participants provided written informed consent. The Ethics Committee of the University Hospitals Leuven (Belgium) approved the study protocol published elsewhere.[18] In short, the nursing staff at a lead–acid battery manufacturing and recycling plant in the United States enrolled (2015–2017) new hires for detailed health evaluations before blood lead elevations associated with occupational exposure. By May 1, 2017, 336 of 490 invited men (68.6%) consented to participate. Of those, we excluded 100 workers, who declined ambulatory BP monitoring (n = 24) or who had fewer than 7 or 3 ambulatory readings during wakefulness and sleep (n = 56), patients on antihypertensive drug treatment (n = 13) and workers with blood lead measurement not yet available at the time of writing of this article (n = 7). The number of workers statistically analyzed, therefore, totaled 236.

Office BP Measurement

Office BP was measured according to current guidelines[20–22] with application of a stringent quality control program.[23,24] At the enrolment visit, nurses measured the workers' upper arm circumference. Standard cuffs had a 12 × 24 cm inflatable portion, but if upper arm girth exceeded 31 cm, larger cuffs with 15 × 35 cm bladders were used. BP measurements were obtained on the nondominant arm, unless at recruitment, the systolic or diastolic BP differences between both arms were 10 mm Hg or more. In this case, the cuffs for office and ambulatory BP measurement were applied to the arm giving the highest BP reading. After the workers had rested for 5 minutes in the sitting position, nurses obtained five consecutive BP readings to the nearest 2 mm Hg, using a standard mercury sphygmomanometers. The five readings were averaged for analysis. Heart rate was counted over 15 seconds. Terminal digit preference and number preference were the criteria applied for quality control of the office BP. Terminal digit preference refers to the observer rounding off the BP reading to a digit of her or his choosing, most often five or zero.[23,24] Number preference refers to the number of identical BP readings made by an observer within participants.[24]

At the enrollment visit, nurses administered standardized questionnaires providing information on each worker's medical history, smoking and drinking habits, use of medications, and previous occupational exposure. Body mass index was weight in kilograms divided by squared height in meters. The waist-to-hip ratio was waist circumference divided by hip circumference.

Ambulatory BP Monitoring

The ambulatory BP was recorded using validated[25] oscillometric Mobil-O-Graph 24-hour PWA monitors (I.E.M. GmbH, Stolberg, Germany), which were programmed to obtain readings at 15-minute intervals during waking hours and every 30 minutes during sleep. On monitoring days, the workers kept a diary, in which they recorded the beginning and end of sleep. If the ambulatory recordings were longer than 1 day, only the first 24 hours were analyzed. The same SAS macro processed all recordings. Intra-individual means of the BP readings over 24 hours and during the awake and asleep periods were weighted by the time interval between successive readings.[26]