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High Job Strain and Ambulatory Blood Pressure in Middle-Aged Men and Women From the Belgian Job Stress Study

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Learning Objectives

- Give examples of what previous studies have demonstrated about the relationship between perceived job strain and blood pressure (BP).
- Compare the results of 24-hour ambulatory BP monitoring at work, at home, and during sleep as well as casual BP measurements in workers with and those without self-perceived job strain as estimated by questionnaire responses.
- Explain whether and to what extent the association between perceived job strain and BP was influenced by the physical demands of the job.

Abstract

Objective: *The aim of this study was to assess whether job strain is associated with 24-hour ambulatory blood pressure measurements within a subsample of the Belgian Job Stress Project (BELSTRESS) population.* ***Methods:*** *A group of 89 middle-aged male and female workers perceiving high job strain and an equally large group of workers perceiving no high job strain wore an ambulatory blood pressure monitor for 24 hours on a regular working day.* ***Results:*** *Mean ambulatory blood pressure at work, at home, and while asleep was significantly higher in workers with job strain as compared with others. The associations between job strain and ambulatory blood pressure were independent from the covariates.* ***Conclusions:*** *Within this study, high job strain was an important independent risk factor for higher ambulatory blood pressure at work, at home, and during sleep in a group of men and women.* (J Occup Environ Med. *2007;49:360–367*)

There is convincing evidence in the literature that psychosocial factors play an important role in the incidence and progression of coronary heart disease.[1–3] A considerable part of this research concentrates on the link between occupational stressors and cardiovascular disease. The introduction of the job demand-control model by Karasek in the 1970s gave impetus to more epidemiological studies in this field.[4–6] According to this model, the most adverse health effects are expected when workers are exposed to high psychological demands in combination with low decision latitude or job control; this combination is labeled as "high job strain." Numerous studies have used Karasek's job strain model to investigate associations between job strain and cardiovascular disease. Several reviews came to the conclusion that the evidence of an association is strong and consistent in men, while results in women are sparse and less consistent.[7–9] According to these reviews, the strongest empirical evidence concerning potential mediating mechanisms in the association between job strain and cardiovascular disease is found for elevated blood pressure (BP), particularly when assessed through ambulatory measurements. It is known that BP levels are notably related to lifestyle factors such as salt and alcohol consumption, excess body fat, and physical inactivity; and although the role of psychosocial stress is less clear, job strain is considered a likely risk factor for hypertension.[10]

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When evaluating studies linking occupational stress to casual BP measurements, results are generally not very consistent. Positive associations between job strain and hypertension or BP levels have been found in some[11–13] but not in all studies.[14–18] The evidence is much more consistent when BP is measured using discontinuous ambulatory recordings during several hours. A number of studies have shown higher levels of ambulatory BP in workers perceiving high job strain according to the demand-control model as compared with others.[19–25] Significant associations were also found when job strain was identified through objective classification of occupations.[26,27] On the whole, the relationship between occupational stress and higher BP in women is rather ambiguous compared with that in men.[28,29]

Within the BELSTRESS study, comprising 21,419 middle-aged men and women, no associations were found between high job strain and casual measures of BP.[30] Higher job demands were related to higher BP levels, but only in men. The aim of this study was to assess whether the perception of job strain is associated with 24-hour ambulatory BP measurements within a subsample of the BELSTRESS population.

Materials and Methods

Study Population and Data Collection

The association between job strain and ambulatory BP was assessed using cross-sectional data from BELSTRESS, an epidemiological cohort study about job stress, cardiovascular disease, sickness absence, and other health issues.[31,32] The second phase of this study was conducted in 2002 and 2003. A total number of 2821 men and women between 40 and 64 years old, working in 9 companies or public administrations across Belgium, who participated in the first survey, were involved. All participants volunteered to complete a self-administered questionnaire and go through a bioclinical examination. A participation rate of 68.5% was reached. The ethics committees of the University Hospital of Ghent and the Faculty of Medicine of the Free University of Brussels approved the BELSTRESS study.

Perceived stress at work was measured by means of the Job Content Questionnaire (JCQ), based on Karasek's job strain model.[6,33] Psychological job demands were measured by nine items. Job control or decision latitude is composed of two subscales: "skill discretion" (six items) and "decision authority" (three items). Based on the gender-specific median split of both JCQ scales, participants perceiving high job strain (high demands combined with low control) were differentiated from others (low job strain, actives, and passives). Five JCQ items composing the scale of physical demands of the job were also included in the questionnaire.

The questionnaire contained additional information on educational level (low, medium, or high). Low education was defined as primary school level only, medium education as secondary school level, and high education as high school or university. Occupations were defined according to the International Standard Classification of Occupations and grouped into executives, white collar, and blue collar.[34] Participants were asked about their regular alcohol consumption and smoking status (current smokers vs others). Stress outside work was measured by a scale based on eight items regarding problems in the private life.[35] Feelings of depression were rated based on 11 items from the Center for Epidemiologic Studies—Depression scale.[36] Sleep problems were assessed by two items.

Participants were medically examined by trained members of the research team, using standardized methods. The medical visit took place in the medical office at the workplace. Body mass index was calculated as body weight (kg) divided by the square of the height (m). Casual systolic and diastolic BP was calculated as the average of two subsequent readings in a sitting position.

Subsample and 24-Hour Monitoring Procedure

From the study group of 2821 participants, a sample was selected for the substudy with ambulatory BP measurements. People taking medication for elevated BP or for hypotension were excluded from the substudy. Participants with a previous hospitalization for coronary heart disease were also considered ineligible. There were no other exclusion criteria. Eligible persons were invited to participate by means of a personal letter, in which the content of the substudy was described. A group of 89 workers perceiving high job strain was randomly selected from the participants within 4 companies. An equally large group of workers perceiving no high job strain were matched for gender, occupation, and company as closely as possible. This population of 178 participants comprises 65.6% of the invited subjects.

At the start of a regular working day, a trained member from the research team initiated the 24-hour monitoring procedure at the workplace. For 24 hours, participants wore a SpaceLabs Medical ambulatory BP monitor (Model 90121, SpaceLabs Medical, Inc., Redmond, WA). The monitor was programmed to measure the arterial BP every half hour during the day (from 6 AM until 10 PM) and every hour at night (from 10 PM until 6 AM). During the day, every measurement was preceded by a warning tone. Participants were asked to keep their arm motionless and in a vertical position beside the body every time they heard the tone. In case a measurement failed due to excessive motion of the body, a new reading automatically followed a few minutes later. Before the automatic measurements started, two subsequent test readings were manually

initiated to make participants familiar with the process. In order to measure the physical activity during the 24-hour monitoring, a Computer Science and Applications activity monitor (Model 7164, Computer Science and Applications, Inc., Shalimar, FL) was attached to the waist. This single-channel Actigraph continuously records accelerations of the body and has been proven a valid tool in assessing physical activity.[37]

Participants were asked to perform their regular activities at work and at home during the monitoring period, and not to detach the devices until the next day. They were also asked to register their 24-hour schedule (time spent at work, at home, and sleeping) in a diary.

Statistical Analyses

The editing criteria of the SpaceLabs monitor were set to reject readings when systolic BP was >240 mm Hg or <70 mm Hg and when diastolic BP was >150 mm Hg or <40 mm Hg. Based on the information from the diaries, the average ambulatory BP of every participant was calculated for the periods at work, at home, and during sleep. The average sleep BP could not be calculated for three participants because there were no valid readings at night. Apart from this, there were never less than two readings and in at least 90% of the participants 5 readings or more for the averages at work, at home, and while asleep. The average number of readings was 16 ± 3 for the work period, 14 ± 3 for the home readings, and 7 ± 2 for the readings during sleep.

The activity monitor was programmed to register an activity count on every minute during the 24-hour monitoring. In all participants, the average physical activity level preceding every ambulatory BP reading was assessed. For each reading, we calculated the average of the count during the reading and the counts on the 5 minutes preceding the reading. On group level, the mean of the average activity levels was assessed for the work, home, and sleep periods. Natural logarithm (ln) transformations were performed because of the skewed distributions.

As for the main analyses, χ^2 and *t* tests were performed to compare workers with and without job strain in terms of descriptive characteristics and risk factors for high BP. Crude and adjusted means of ambulatory BP were evaluated in both groups using analyses of variance (ANOVAs). We assessed all possible interactions between job strain and other risk factors in relationship to ambulatory BP. Adjusted associations were evaluated between ambulatory BP and quartile groups of job demands and job control, and quadrant groups of job strain. All analyses were conducted using SPSS 12.0 software (SPSS, Inc., Chicago, IL).

TABLE 1
Descriptive Characteristics of the High Job Strain Group (n = 89) and Others (n = 89)

Characteristics	High Job Strain	No High Job Strain	*P* Value
Gender, % (n)			0.44
Men	64.0 (57)	58.4 (52)	
Women	36.0 (32)	41.6 (37)	
Age (yr), mean (SD)	51.9 (4.3)	50.9 (5.0)	0.18
Educational level, % (n)			0.26
Low	38.6 (34)	39.1 (34)	
Medium	40.9 (36)	31.0 (27)	
High	20.5 (18)	29.9 (26)	
Occupation, % (n)			0.68
Executives	8.0 (7)	8.0 (7)	
White-collar	63.6 (56)	69.3 (61)	
Blue-collar	28.4 (25)	22.7 (20)	
Sector of employment, % (n)			0.93
Secondary	20.2 (18)	18.0 (16)	
Tertiary	12.4 (11)	12.4 (11)	
Public	67.4 (60)	69.7 (62)	
Body mass index (kg/m^2), mean (SD)	26.5 (3.8)	25.8 (3.2)	0.22
Current smoker, % (n)	31.5 (28)	15.7 (14)	0.01
Alcohol consumption (units/wk), mean (SD)	12.0 (9.7)	12.1 (11.9)	0.92
High physical demands of the job, % (n)*	24.7 (22)	13.6 (12)	0.06
High levels of stress outside work, % (n)*	34.1 (30)	18.0 (16)	0.02
High levels of feelings of depression, % (n)*	36.0 (32)	14.8 (13)	<0.001
Sleep problems, % (n)*	30 (33.7%)	18 (20.2%)	0.04
Activity count prior to BP measurements (ln), mean (SD)	5.36 (0.54)	5.25 (0.54)	0.18

*Upper quartile of the scale.
SD indicates standard deviation; BP, blood pressure.

Results

Table 1 shows the descriptive characteristics and risk factors for elevated BP in those with high job strain (89 workers) and others (89 workers). The high job strain group contained significantly more current smokers, more workers with high physical job demands, more people with high stress outside work, more with high feelings of depression, and more with severe sleep problems.

In both groups, the highest mean ambulatory BP was observed at work, followed by ambulatory BP at home and during sleep (Table 2). Ambulatory BP at work was significantly higher in workers with job strain as compared with others, with differences of 6.5 mm Hg in systolic BP and 3.1 mm Hg in diastolic BP.

TABLE 2
Crude and Adjusted Associations Between Job Strain and Ambulatory Blood Pressure (mm Hg)

	Crude Means (SD)			Adjusted Means*		
	High Job Strain	No High Job Strain	*P* Value	High Job Strain	No High Job Strain	*P* Value
Ambulatory systolic BP						
At work	134.3 (12.2)	127.8 (10.5)	<0.001	135.2	129.3	<0.001
At home	131.7 (11.5)	127.2 (9.4)	0.01	133.1	129.3	0.02
During sleep	115.9 (11.9)	110.4 (10.7)	<0.001	118.0	113.5	0.02
Ambulatory diastolic BP						
At work	86.6 (9.3)	83.5 (8.1)	0.02	86.4	83.4	0.03
At home	83.8 (8.3)	81.6 (7.4)	0.07	84.0	81.9	0.10
During sleep	70.7 (8.7)	66.6 (7.7)	<0.001	71.3	67.4	0.01

*Adjusted for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, and mean level of physical activity prior to blood pressure measurements.
SD indicates standard deviation; BP, blood pressure.

The significant increase in ambulatory BP in the high job strain group was maintained during the periods at home and while asleep; the difference for the diastolic BP at home, though, was only borderline significant. In multivariate ANOVAs, adjusted means were controlled for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, and mean level of physical activity prior to blood pressure measurements. The differences in ambulatory BP between workers with and without job strain remained highly significant after adjusting for covariates. Since educational level, occupation, company, and alcohol consumption did not discriminate between the job strain groups, these variables were not included in the model. No adjustments were made for depressive feelings and sleep problems, because additional analyses indicated that these factors did not play an intermediate role in the association between job strain and BP.

Casual BP at the worksite (results not shown here) was also higher in the high job strain group, with differences of 4.3 and 0.7 mm Hg in adjusted mean systolic and diastolic BP as compared with others; however, these differences did not reach statistical significance. Moreover, the association between job strain and ambulatory BP at work was independent from casual worksite BP.

In multivariate analyses, several other risk factors in addition to job strain proved to be important determinants of ambulatory BP. Concerning systolic BP, positive associations were assessed with body mass index and physical demands of the job, whereas diastolic BP was positively related to alcohol consumption and male gender. After adjustments for job strain and covariates, a borderline significant relationship between stress outside work and diastolic home BP was found ($P = 0.08$), with a difference of 2.5 mm Hg between people with high stress outside work and others.

None of the terms of interaction between job strain and other risk factors in relationship to ambulatory BP were significant. It should be noted, though, that the association between job strain and diastolic BP was larger in older participants, with a significant elevation of 5.0 mm Hg in diastolic BP at work in subjects aged 50 years or older opposed to a not significant elevation of 0.7 mm Hg in others. Also, job strain was not related to ambulatory diastolic BP in workers with high physical job demands, whereas a significant elevation of 3.5 mm Hg in BP at work was found in others.

No significant interactions between job demands and decision latitude in relationship to ambulatory BP were found. Consequently, the association between high job strain and higher BP was mainly due to the additive rather than the interactive effects of both components of the demand-control model. The adjusted mean ambulatory BP at work for the quartiles of job demands and job control is shown in Table 3. Strong and significant associations were primarily found between low job control and higher BP at work, with differences of 11.7 mm Hg in systolic BP and 6.7 mm Hg in diastolic BP between the first and the last quartile group. In addition, the differences between the extreme quartile groups of job control—but not job demands—were significant regarding adjusted mean systolic BP at home and systolic and diastolic BP during sleep (results not shown here). Moreover, the associations between decision latitude and ambulatory BP remained significant after additional adjustment for job demands.

The predominant role of low decision latitude in the association between high job strain and ambulatory BP was confirmed when mean systolic and diastolic BP was compared between the job strain quadrant groups (Figs. 1 and 2). Highest mean systolic and diastolic BP at work was found in the groups with low job control: the high strain group (136.4/87.4 mm Hg) followed by the passive group (133.5/86.1 mm Hg). These groups were closely related to each other

TABLE 3
Adjusted Associations Between Quartiles of Job Demands, Job Control, and Ambulatory Blood Pressure at Work (mm Hg)

	Adjusted Means*			
	Systolic BP at Work	*P* Value	Diastolic BP at Work	*P* Value
Job demands		0.04		0.18
Quartile 1	129.7		83.8	
Quartile 2	130.7		84.5	
Quartile 3	135.1		86.1	
Quartile 4	136.2		88.0	
Job control		<0.001		0.02
Quartile 1	139.2		88.9	
Quartile 2	132.3		85.4	
Quartile 3	132.9		85.9	
Quartile 4	127.5		82.2	

*Adjusted for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, mean level of physical activity prior to blood pressure measurements, and occupation.

BP indicates blood pressure.

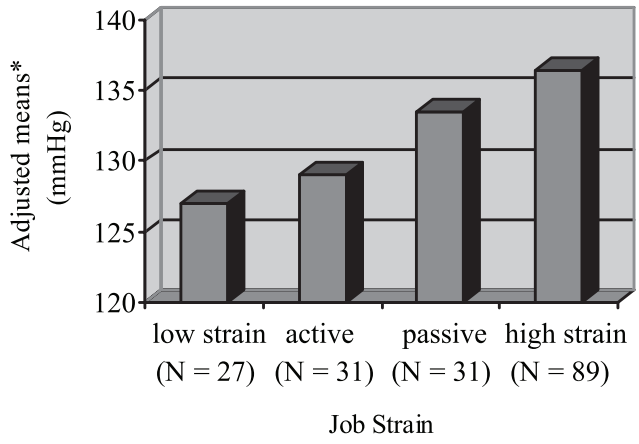

Fig. 1. Adjusted association between quadrant groups of job strain and mean systolic blood pressure at work (mm Hg). *Adjusted for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, mean level of physical activity prior to blood pressure measurements, and occupation.

in terms of ambulatory BP at work and diverged substantially from the active group (129.0/83.9 mm Hg) and the low job strain group (127.0/82.0 mm Hg).

Discussion

The aim of this study was to explore perceived job strain according to the demand-control model in relationship to ambulatory BP within a sample of middle-aged men and women. Ambulatory BP measurements within 24-hours were evaluated in a group of 89 workers with high job strain and in an equally large number of workers perceiving no high strain. We detected strong and consistent associations between high job strain and ambulatory BP. The impact was not limited to an increased BP at work; mean ambulatory BP at home and during sleep were also higher in workers with high strain. It is important to note that the associations in this study were independent of other risk factors of high BP (ie, gender, age, body mass index, smoking, physical demands of the job, stress outside work, and physical activity prior to BP measurements.) With the use of the activity monitor, proper adjustment for physical activity could be attained. Physical activity is an essential determinant of ambulatory BP, and several studies have shown strong correlations between ambulatory BP and average physical activity prior to the measurement.[38–40] Consequently, it is highly recommended that ambulatory BP data be interpreted in the light of activity data averaged over the minutes preceding BP assessments. A study with ambulatory BP monitoring and actigraphy in 160 subjects found that physical activity during the BP measurement and the preceding 5 minutes was the best predictor of the within-person fluctuations in ambulatory BP, an approach which we followed in processing the data.[39]

The highest mean systolic and diastolic BP measurements were observed at the workplace, followed by mean systolic and diastolic BP at home and during sleep, which is in line with expectations.[41,42] The effect sizes in our study—differences of 6.5 and 3.1 mm Hg in systolic and diastolic BP at work between the high job strain group and others—were very similar to those found in the Work Site Blood Pressure Study, a study with 24-hour ambulatory BP measurements in 264 men from 8 New York work sites.[19]

A similar impact of job strain on ambulatory BP was found in both men and women. Thus, the results of this study suggest that perceived job stress is a risk factor for higher BP not only in men but also in women, contrary to some other studies that highlight the inconsistent findings in women.[28,29]

In a number of studies, job stress measures were related to systolic ambulatory BP whereas no association was found with diastolic BP.[22,43–45] High job strain within our population resulted in significant elevations in both systolic and diastolic BP, although the associations with diastolic BP were smaller.

Our results support the idea that ambulatory measurements of BP are

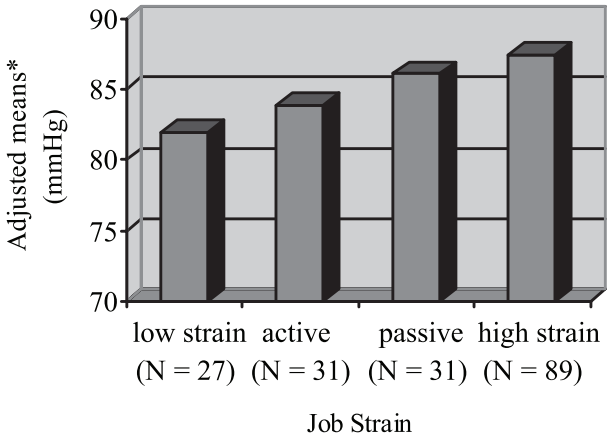

Fig. 2. Adjusted association between quadrant groups of job strain and mean diastolic blood pressure at work (mm Hg). *Adjusted for gender, age, body mass index, smoking, high physical demands of the job, high stress outside work, mean level of physical activity prior to blood pressure measurements, and occupation.

more appropriate than casual assessments to explore associations with job stress, which confirms other studies.[24,46] Only ambulatory BP, but not casual worksite BP, was consistently and independently higher in workers with high job strain. It is generally accepted that ambulatory monitoring results in a more accurate characterization of an individual's BP because it is based on multiple assessments during normal life activities and also because the "white-coat effect" is avoided.[47]

Contrary to job strain, the perception of stress outside work as measured in this study did not seem to be an essential determinant of ambulatory BP. Regarding diastolic BP at home, though, both job strain and stress outside work generated comparable, borderline significant effects. Job strain was strongly related to feelings of depression, as was found in many other studies.[48] However, we were unable to discover any relationship between feelings of depression and ambulatory BP. Thus, this study underlines the importance of the psychosocial work environment in contrast to psychological variables in relation to BP, which is in line with findings from the Work Site Blood Pressure Study.[49]

Although the interaction term was not statistically significant, the impact of job strain on diastolic BP was considerably more pronounced in workers aged 50 years or older. The Work Site Blood Pressure Study also found greater effects of job strain on BP with increasing age.[11,19] In workers with high physical demands of the job, job strain did not result in higher diastolic BP. The same finding was reported by Theorell in a study including 161 men with borderline hypertension.[26] Several studies have reported modifying effects of socioeconomic status in the relationship between job stress and BP. Within the Work Site Blood Pressure Study, larger associations between job strain and ambulatory BP were found in men with lower socioeconomic status.[50,51] Gallo et al only found an association between job strain and ambulatory BP in women in lower occupations.[45] Two studies including white-collar women reported that high job strain was only related to ambulatory BP in women with a higher educational level.[52,53] No interaction between job strain and socioeconomic status in relationship to BP was found in our study. High job strain was associated with increased ambulatory BP in all occupational groups and educational levels.

A number of studies have emphasized the confirmation of Karasek's demand-control model regarding ambulatory BP, since only the combination or interaction of job demands and decision latitude resulted in higher BP, while no independent effects of the separate components were observed.[11,19–21,26,43] The association between high job strain and ambulatory BP in our study, however, was due to the additive effects of job demands and job control; no significant interactions were found. The negative association between ambulatory BP and decision latitude was especially consistent and independent of covariates. The predominant role of low job control in association with ambulatory BP in men and women was also discovered by Steptoe et al.[54]

The results of this study confirmed that high job strain is causally related to higher ambulatory BP. Nevertheless, possible alternative explanations should be considered. When exposure to job stress is assessed through self-reports, it is essential that awareness of having hypertension and treatment for the disease are accounted for, because these conditions are likely to cause information bias.[55] People with hypertension who are labeled as having high BP might give biased responses to questions regarding work stressors. None of the participants in this study were medically treated for hypertension. A total of 20 subjects from the high job strain group reported that a physician once told them that they have elevated BP. However, additional adjustment for this condition of awareness of elevated BP only marginally changed the results regarding job strain and ambulatory BP.

Participants in the BELSTRESS study were not recruited from a representative sample of the active working population in Belgium, which may limit the external validity of the results. Nonetheless, the study cohort covers a broad range of companies and occupational groups. As for the selection of participants in the substudy, a considerable rate of response was reached as two of three invited workers were willing to participate. Moreover, in all probability there was no severe se-

lection bias, since no differences concerning general characteristics and perception of job stress were found between the high job strain and the no high job strain group in the substudy and their equivalents in the total population.

The results presented here are based on a single assessment of perceived job strain. This increases the risk of misclassification due to inaccuracy in measurement, a result of which the associations found here are likely underestimations, or at least conservative estimates of the truly existing relationships between job stress and BP.[56] Longitudinal analyses concerning job strain and ambulatory BP were performed within the population of 195 men from the Work Site Blood Pressure Study.[23] Participants with cumulative exposure to job strain on two occasions 3 years apart had higher ambulatory BP on the second occasion than those exposed to job strain at only one assessment. Negative findings were reported in a longitudinal study including 292 men and women, in whom job strain at baseline was not related to ambulatory BP after a 5-year follow-up period.[57] Further research with longitudinal study designs is needed in order to clarify the exact nature of the relationship between job strain and BP.

Conclusion

In conclusion, based on this study and other studies, there is convincing evidence for consistent associations between self-perceived job strain and ambulatory BP. Within this study, high job strain was an important independent risk factor for higher BP at work, at home, and during sleep in a group of men and women. Our results suggest that low decision latitude plays the predominant role in the association. Although the effect sizes found in our study may not be clinically relevant on the individual level, they are very significant in a public health approach. It has been estimated that a reduction in systolic BP of about 10 mm Hg (or 5 mm Hg diastolic BP) results in about a 20% to 25% lower risk of coronary heart disease, and that half of coronary heart disease worldwide is attributable to nonoptimal BP.[58]

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