

Family history of hypertension — an individual trait interacting with spontaneously occurring job stressors

by Töres Theorell, MD¹

THEORELL T. Family history of hypertension — an individual trait interacting with spontaneously occurring job stressors. *Scand J Work Environ Health* 1990;16(suppl 1):74—9. Family history of hypertension has been associated with enhanced blood pressure reactivity and a “noncomplaining” life attitude. The present empirical study supported the notion that enhanced blood pressure reactivity is associated with other endocrinologic hormonal reactivity patterns (plasma cortisol, prolactin, and testosterone) not directly related to blood pressure during increasing job strain (demands/decision latitude). Furthermore, it was found that noise effects on blood pressure rise at work occur mainly among people with a family history of hypertension. Interaction between stressors and individual characteristics seems important in the analysis of the health effects of job stressors, and “family history of hypertension” seems to be an important individual characteristic not only of blood pressure associations but also of other relationships between job environment and health.

Key terms: blood pressure, cortisol, family history, job demands, noise, prolactin, stress, testosterone.

In epidemiologic and psychophysiological research on psychosocial stressors and heart disease risk it has become increasingly clear that interactions between individual traits and environmental factors are of great importance. For instance, subjects with type A behavior react differently to a number of experimental stressors than do other subjects (1), and recently, in a yet unpublished study from the National Institute for Psychosocial Factors and Health and the Karolinska Institute (“Type A Behavior, Social Support and Coronary Risk: Interaction and Significance from Mortality in Cardiac Patients” by Orth-Gomér & Undén), it has also been shown that subjects with type A behavior and poor social support may have a much higher risk for coronary heart disease death than others. In both of these examples important associations may be entirely overlooked if interactions are not analyzed.

In most of the cases in which interactions between individual traits and environmental stressors have been studied, traits that exaggerate both the experience of the stressor and the physiological reaction to it have been considered. Type A behavior may be an example of this occurrence. There are, however, also examples of traits that may be associated with an underreporting of the stressor but are still associated with an overreaction physiologically. Such traits are of course of particular significance. If these interactions are overlooked, the importance of an environmental factor may be seriously underestimated. In this paper

family history of hypertension has been discussed as an example of the second group of traits. Family history of hypertension is easy to identify since most subjects in the industrialized world know whether they have a family history of hypertension.

Family history of hypertension has proved to be strongly associated with an increased risk of developing high blood pressure. During recent years psychophysiological research has also shown that persons with normal blood pressure who belong to families with at least one family member with hypertension react with more blood pressure elevation in stressful situations than others (2—4). It is not known to what extent such an enhanced reactivity may be inherited biologically and to what extent it may be acquired. That part of the blood pressure reactivity may be biologically inherited is supported by a study on a series of monozygotic and dizygotic twins who were subjected to a stress interview. In the monozygotic twin pairs — but not in the dizygotic pairs — blood pressure similarity increased progressively during the stress interview (5). This result may support the notion that the reactivity may be to some extent biologically inherited. On the other hand, during recent years research has also shown that there are special emotional characteristics in persons in an early stage of asymptomatic hypertension and in nonhypertensive persons belonging to “hypertensive” families. Such characteristics of individual family members may be of importance to the psychosocial environment of the whole family, and socially inherited mechanisms may therefore operate as well. For instance, Knox et al (6) in an epidemiologic study have shown that 28-year-old men in an early stage of asymptomatic hypertension differ from men of the same age with regard to emotional coping. They report less joy and express sorrow

¹ National Institute of Psychosocial Factors and Health, Stockholm, Sweden.

Reprint requests to: Dr T Theorell, National Institute of Psychosocial Factors and Health, Box 60205, S-104 01 Stockholm, Sweden.

to fewer people than 28-year-old men with normal blood pressure. In general they show less ability to differentiate feelings and to deal constructively with them in real life situations. Furthermore, Jorgensen & Houston (3) have shown that normotensive subjects who are members of "hypertensive" families report fewer emotions than other subjects. There is evidence from a study based on randomly selected men in Göteborg (7) that asymptomatic hypertensive men report fewer bodily symptoms than others. In families with such members there will accordingly be fewer discussions of emotional reactions and bodily symptoms. It is likely that this situation may have an important impact on the psychosocial processes in the family. It has been speculated that similar processes could arise in the workplace as well. If the psychosocial work environment enforces a noncomplaining attitude and prevents development of active emotional coping, the result could be an adverse effect on the long-term development of health in these individuals due to the longlasting physiological tension that is generated.

Noncomplainers

In the past, the noncomplaining tendency of subjects prone to develop hypertension may have been of phylogenetic benefit. Persons who react vigorously with their blood pressure to threats and who do not complain but rather act in a concrete way to remove the threat may have been important to the survival of the group in the past. They may have been the ones who were willing to face the most threatening challenges. In modern worklife, on the other hand, such a reaction pattern may not be compatible with good health in the long run although it may still be a useful way of handling stress in the acute emergency situation.

"Noncomplaining" may also be associated with a number of other physiological reactivity characteristics that have been insufficiently explored so far. In the present study the objective was to examine whether subjects with a family history of hypertension differ from other persons with regard to three different hormonal reactions to job strain and whether they differ from others with regard to blood pressure reactions to noise at work. The hormones selected for study were cortisol, prolactin, and testosterone.

Cortisol

The excretion of cortisol from the adrenal cortex has been shown to be sensitive to a number of psychosocial stressors. In general, situations characterized as novel and distressing are associated with increased cortisol production (8). Thus it could be assumed that persons who react to distressing situations with a marked elevation of cortisol production are aware — in some meaning — of the distressing nature of the situation, whereas persons who are less aware of the distress

would react with less an elevation of cortisol production.

Prolactin

The hypophyseal excretion of prolactin is associated with the regulation of emotions in some way that is not well understood. Some studies have shown increased and other studies decreased prolactin levels during conditions of stress and exhaustion. Prolactin is important to the regulation of dopamine levels in the brain, and it is known that it is also important to the regulation of blood pressure levels during pregnancy when the levels are very high (9). Research on mice has shown that prolactin levels are elevated during conditions of ecological stress in animals which are dominated and defeated (10). Psychiatric research has shown that conditions of depression and withdrawal are associated with high prolactin levels (11). Thus it could be assumed that persons who tend to feel depressed during conditions of stress would tend to react with increased prolactin levels. On the other hand persons — for instance those with a family history of hypertension — who would tend not to be aware of difficulties would react with less elevation of or even with a decrease in prolactin excretion.

Testosterone

Testosterone has important anabolic functions. During emergency situations the anabolism is inhibited because the metabolism is needed for the supply of fuel for physical action. Early studies by Mason (12) on monkeys showed that the excretion of male sex hormone tended to decrease when the animals were subjected to restrain stress. At the same time the excretion of typical catabolic hormones was stimulated. Testosterone production has been observed to decrease in young men during periods of serious unavoidable stress [American soldiers in the Vietnam war (13)]. Thus it could be assumed that men who prepare themselves for action in a more active way than others during a stressful period would also tend to have a more decreased testosterone production than other men.

The aim of the endocrine part of this study was thus to elucidate the interaction between family history of hypertension on one hand and changes in endocrine activity on the other during a stressful period. The area of life selected for study was the work setting. A hypothesis initially formulated by Karasek (14) implies that increasing psychological demands at work may be harmful to health only when the environment provides little possibility to exert influence over the situation — decision latitude. The ratio between psychological demands and decision latitude has been operationally defined as job strain. The objective was to test the hypothesis that men with a family history of hypertension differ from other men not only with regard to blood pressure reactions to occupational strain, but also with regard to endocrine reactivity patterns.

More specifically the goal was to test whether "non-complaining" is associated with specific endocrine reactivity patterns.

In the present study there was also the opportunity of testing the association between blood pressure elevation at work (compared with the levels during leisure time) and noise exposure and how this association interacts with family history of hypertension. The hypothesis was that the blood pressure elevation associated with noise exposure would be much more marked in subjects with a family history of hypertension than in other subjects.

Methods

Longitudinal study of job strain

The longitudinal study of self-monitored blood pressure during work and leisure hours and of endocrine factors has been presented in detail elsewhere (15, 16). Fifty-one men, mean age 41.4 (SD 10.0) years, and 22 women, mean age 36.6 (SD 9.6) years, participated on four measurement occasions. They were recruited from six different occupations (symphony orchestra musicians, air traffic controllers, physicians, freight handlers, waiters, and airplane mechanics) with similar age distributions. Blood sampling (antecubital vein) was performed by a licensed nurse at the worksite before work started, mostly between 0730 and 0900. Samples were frozen within an hour of the sampling. Plasma cortisol, prolactin, and total testosterone were analyzed by means of radioimmunoassay. In the present report only the results of the men have been included for the endocrine study. Due to the skewed distributions of plasma cortisol and prolactin concentrations the statistical computations of these variables were performed after logarithmic transformation. Blood pressure was measured by means of self-triggered equipment by the participants themselves at regular intervals during workhours and during leisure time, and the means were calculated for work and leisure activity separately. The used instruments were calibrated and checked at regular intervals. Systolic blood pressure measured in the conventional way on the same occasion by trained personnel showed good agreement with that of the person's own measurement.

Participants were recruited to the study over a nine-month period. The rationale of this procedure was to ensure that the longitudinal findings would not be due to seasonal variations in biological and psychological parameters. Job strain was measured by means of a Swedish version of a demand/decision latitude questionnaire originally constructed by Karasek (17) on the basis of the American Quality of Employment Survey in 1977. Job strain was computed by means of division of the score of psychological demands by the score of decision latitude. Subsequently, each person's four observations were rated with regard to job strain. The worst to least strainful occasions were randomly distributed with regard to the first to the fourth measure-

ment occasion. Thus possible relationships between job strain and physiological parameters could not be due to differences in the subject's acquaintance with procedures, etc. The hour of sampling did show variations, and these variations could be of importance to the endocrine results. However, the variation in sampling hour across job strain was random. Furthermore, change in sampling hour was used as an explanatory variable in the multivariate regressions. Since it did not change any of the presented results significantly, it will not be mentioned further.

Participants were also asked about smoking habits and the ingestion of strong liquor, wine, and beer on all the occasions. Furthermore, the serum concentration of gamma glutamyltranspeptidase was measured. The results of the analyses of smoking habits and alcohol consumption (both self-reported and "objective" on the basis of liver enzyme concentrations) did not indicate any significant changes in relation to job strain. Four subjects in the group with a family history of hypertension and one subject in the remaining group were on constant medication that could be of significance to reactivity (beta blockers and diuretics). Whenever the exclusion of these subjects had a significant impact on the results, it has been mentioned specifically.

"Depressive tendency" was recorded by means of a diary. Subjects who reported at any time during the four measurement days that they felt depressed or sad were operationally defined as subjects with a depressive tendency.

"Sleep disturbance" was recorded by means of a questionnaire. A total score ranging from 0 to 23 was calculated for each measurement occasion.

Study of noise

The study of noise was part of the same study as the longitudinal study of job strain. It, however, comprised a larger sample of subjects since in this case participation on four occasions was not required (18). The analysis of relationships with noise was based upon the responses of those who participated on the second measurement occasion ($N = 100$) when questions regarding noise were made. The question used was "Is it noisy in your workplace?" There were five response categories ranging from "never" to "daily." The distribution of responses approached a normal distribution, slightly skewed towards the right side. In the dichotomized analyses the upper two categories "often" to "daily" were compared with the three lower categories "never" to "sometimes." The reliability of the noise question was measured by means of a repeated question after six months. The reliability was acceptable (repeatability coefficient 0.79). In the noise study all the available blood pressure measurements were utilized (from one to four possible measurement days) for the calculation of systolic and diastolic blood pressure at work and the difference between systolic blood

pressure at work and systolic blood pressure during leisure time.

Notes on both studies

Family history of hypertension was recorded by means of one single question: "Has anyone in your family (biological parents or siblings) had hypertension before the age of 60?" Persons who responded yes to this question were defined as having a family history of hypertension.

In both studies the attrition rate was high due to the extensive interrogation and testing that took place. In the total study (not included in the present report) 64 % of the total selection of 327 subjects took part at least once in the study. In the noise study the participation rate was only 31 %, and in the longitudinal job strain study it was only 22 %. Thus the samples studied may not necessarily be representative of their respective occupational groups.

Results

It was shown that systolic blood pressure at work increased successively with increasing job strain. As expected this increase was confined mainly to the 31 % of the studied sample which reported that they had a family history of hypertension. On the occasion with the least job strain there was very little difference in systolic blood pressure during the workhours between those with and those without a family history of hypertension, whereas the difference was more evident during increasing job strain. These findings were expected. In a multivariate analysis it was shown that family history of hypertension — independently of age and depressive tendency — and increase in job strain and change in sleep disturbance from least to worst job strain predicted a significant part of the increase in systolic blood pressure at work from least to worst job strain (15).

The findings for plasma cortisol indicated that men with a family history of hypertension had significantly lower plasma cortisol levels on the occasion with the worst job strain than did other men.

The findings for prolactin indicated that the 17 % (N=8) of the men who reported a depressive tendency in their diaries had a striking successive increase in prolactin concentrations with increasing job strain. The same phenomenon was not found for the other men. Among the men with a family history of hypertension there was even a tendency for the prolactin levels to decrease with increasing job strain. A multivariate analysis was performed with depressive tendency, family history of hypertension, age, and differences in job strain and sleep disturbance between the occasion with the most and the least job strain, respectively, as explanatory variables and the difference in prolactin concentration between the worst and least job strain as the dependent variable. Both family his-

tory of hypertension and depressive tendency were independent significant predictors of prolactin change. Family history of hypertension explained 9 % of the variance.

The analyses for testosterone, finally, were made with the average plasma concentrations on the two occasions with the most and the two occasions with the least job strain. The rationale for this was the known wide spontaneous fluctuations in testosterone levels. There was a tendency for plasma testosterone levels to decrease with increasing job strain although this tendency was confined to men with sedentary jobs and with a family history of hypertension. In a multivariate analysis using family history of hypertension, sedentary/physically demanding work, age, cigarette smoking index, testosterone concentration on the occasion with the worst job strain, and the peak job strain score as explaining variables and change (ratio) in plasma testosterone concentration from the occasions with the least job strain was used as the dependent variable. Family history of hypertension and sedentary work were both significantly associated with a more pronounced decrease in testosterone levels with increasing job strain. Family history of hypertension explained 15 % of the variance in this analysis. However, this analysis was significant only when subjects on regular medication were excluded. (See "Longitudinal Study of Job Strain" in the Methods section.)

In summary, although the longitudinal study was based upon small numbers and needs to be replicated with the use of other groups, the findings do support the hypothesis that men with a family history of hypertension show a stress response syndrome that is not limited to blood pressure only. The low cortisol levels during peak strain and the lack of prolactin response and the strong decrease in testosterone levels during job strain supported the hypothesis.

Noise exposure

Tables 1 and 2 show the results of multiple regression with age, sex, family history of hypertension, serum gamma glutamyltranspeptidase (as an indicator of excessive alcohol consumption), the ratio between psychological demands and decision latitude at work (job strain), reported coffee consumption, and noise at work as explaining variables. In table 1 systolic and in table 2 diastolic blood pressure at work is the dependent variable. Table 3 shows the corresponding table with the differences between systolic blood pressure during workhours and systolic blood pressure during leisure time as the dependent variable. As expected, age was an important predictor of both systolic and diastolic blood pressure. Sex was also important for systolic blood pressure — as expected the men had a higher systolic blood pressure during work than the women, even when other variables were adjusted for in the multivariate analysis. For diastolic blood pressure during work, demand divided by decision latitude

Table 1. Result of a multiple regression with systolic blood pressure during workhours as the dependent variable, significant steps. Both the men and women (N = 100) are included.

	Adjusted explained variance	
Step 1	Sex	22 %
Step 2	Age	27 %

Table 2. Result of the significant steps of a multiple regression with systolic blood pressure during workhours as the dependent variable. Both the men and women (N = 100) are included.

	Adjusted explained variance	
Step 1	Age	24 %
Step 2	Demands/decision latitude	29 %
Step 3	Log(serum gamma glutamyltranspeptidase)	31 %

Table 3. Result of the significant steps of a multiple regression with systolic blood pressure during workhours as the dependent variable. Both the men and women (N = 100) are included.

	Adjusted explained variance	
Step 1	Noise at work	4 %

Table 4. Effect of noise at work and family history of hypertension on the age-adjusted difference between systolic blood pressure of the men (N = 81) during workhours and systolic blood pressure during leisure time.

Family history of hypertension	Little noise			Much noise		
	N	Mean (mm Hg ^a)	SD	N	Mean (mm Hg ^a)	SD
No	33	4.0	5.5	31	4.4	4.8
Yes	13	3.3	2.5	14	8.6	6.0

^a 1 mm Hg = 0.133 kPa.

and gamma glutamyltranspeptidase were significant predictors. Thus, the more job strain and (presumably) the higher the alcohol consumption, the higher the diastolic blood pressure even when other variables have been accounted for. Thus, in these analyses of blood pressure levels, noise was not an independent predictor. In table 3, however, noise during work is the only variable that shows a significant independent association with elevation in systolic blood pressure from leisure time to worktime after adjustment for other variables.

Table 4 shows the (age-adjusted) rise of systolic blood pressure from leisure time to work among the men who reported much noise at work and among those who reported little noise at work. (See the pre-

ceding text.) There is also a comparison between those with a family history of hypertension and those with no family history of hypertension. Age was used as a covariate. A two-way analysis of variance indicated that family history of hypertension did not influence significantly the rise of systolic blood pressure by itself. Noise at work did show a significant association with systolic blood pressure rise ($P = 0.02$). The most interesting observation, however, was that all the effect of noise on blood pressure elevation took place in the group of men with a family history of hypertension ($P = 0.05$, two-way interaction). It was only in this group that the noise variable had any effect on systolic blood pressure elevation.

Concluding remarks

Subjects with a family history of hypertension differ from others in their way of reacting endocrinologically to psychosocial job strain. The reaction pattern is consistent with a noncomplaining "active" way of responding endocrinologically to strain. At the same time observations indicate that subjects with a family history of hypertension are the only ones that respond with increased systolic blood pressure to self-reported noise at work. It should be remembered that subjects with a family history of hypertension may also be prone to underreport noise because of their noncomplaining life attitude. At least this is a possibility before they have become identified as hypertensives. In the present study asymptomatic nonstigmatized subjects were used.

There are two practical implications of the findings regarding noncomplaining and enhanced general reactivity among subjects prone to develop hypertension (but not yet hypertensive!). The first is that this group (31% in the longitudinal study presented in this report) may complain too late. The exploration of the environment at a worksite should take this fact into account. For instance, a largescale study has shown that bus drivers with hypertension in an early stage (19) may present "too favorable" a description of their work environment. Accordingly, ecological descriptions of the environment should be added to individual descriptions.

The second implication has to do with screening procedures. The blood pressure prone group is very large. Furthermore, although the results of research on personality and blood pressure are somewhat ambiguous and difficult to interpret, findings indicate that early stage hypertensives do not often express anger (20, 21) and in general make more efforts to please the environment than others. Thus, they would tend to be more attractive to an employer than others. The conclusion to be drawn from this is that the identification of such individuals for exclusion from employment in risk jobs is not feasible. Thus, first and foremost, the environment must be improved.

References

1. Matthews KA, Haynes SG. Type A behavior pattern and coronary disease risk: update and critical evaluation. *Am J Epidemiol* 1986;123:923—60.
2. Henningsen NC. Metabolic aspects in genetic hypertension — a study in younger relatives of families with heavy accumulation of essential hypertension [Dissertation]. Lund (Sweden): University of Lund, 1980.
3. Jorgensen RS, Houston BK. Family history of hypertension, personality pattern and cardiovascular reactivity to stress. *Psychosom Med* 1986;48:102—17.
4. Obrist PA. The cardiovascular behaviour interaction — as it appears today. *Psychophysiology* 1976;13:95—107.
5. Theorell T, de Faire U, Schalling D, Adamson U, Askevold F. Personality traits and psychophysiological reactions to a stressful interview in twins with varying degrees of coronary heart disease. *J Psychosom Res* 1979;23:89—99.
6. Knox S, Svensson J, Waller D, Theorell T. Emotional coping and the psychophysiological substrates of elevated blood pressure. *Behav Med* 1988;2:52—8.
7. Tibblin G, Lindström B, Ander S. Complaints in subjects with angina pectoris and hypertension. In: Sanchetti A, ed. *Neural and physiological mechanisms in cardiovascular disease*. Milano: Il Ponte, 1972.
8. Lundberg U, Frankenhaeuser M. Pituitary-adrenal and sympathetic-adrenal correlates of distress and effort. *J Psychosom Res* 1980;24:125—230.
9. Marlettini MG, Cassani A, Morselli-Labate AM, et al. Role of prolactin in pregnancy hypertension. *Clin Exp Hypertens [A]* 1987;9:1099—119.
10. Henry JP, Stephens PM, Ely DL. Editorial review: psychosocial hypertension and the defence and defeat reactions. *J Hypertens* 1986;4:687—97.
11. Lagerström M. Prolactin — en litteraturoversikt 1980—1983 [Prolactin — a literature review 1980—1983]. Stockholm: Department of Psychology, University of Stockholm, 1984.
12. Mason JW. Organization of psychoendocrine mechanisms. *Psychosom Med* 1968;30:565—808.
13. Rose RM, Bourne PG, Poe RO, Mougey EH, Collins DR, Mason JW. Androgen responses to stress II. *Psychosom Med* 1969;31:418—36.
14. Karasek RA. Job demands, job decision latitude and mental strain: implications for job redesign. *Admin Sci Q* 1979;24:285—308.
15. Theorell T, Perski A, Åkerstedt T, et al. Changes in job strain in relation to changes in physiological state: a longitudinal study. *Scand J Work Environ Health* 1988;14:189—96.
16. Theorell T, Karasek RA, Eneroth P. Job strain variations in relation to plasma testosterone fluctuations in working men — a longitudinal study. *J Intern Med* (in press).
17. Karasek RA, Theorell T, Schwartz JE, Schnall PL, Pieper CF, Michela JL. Job characteristics in relation to the prevalence of myocardial infarction in the US HES and HANES. *Am J Publ Health* 1988;78:910—8.
18. Theorell T, Ahlberg-Hultén G, Alfredsson L, Perski A, Sigala F. Bullers effekt på människor [The effect of noise on people]. Stockholm: Department for Stress Research, Karolinska Institute, 1987.
19. Winkleby M, Ragland D, Fisher J, Syme L. Excess risk of sickness and disease in bus drivers: a review and synthesis of epidemiological studies. *Int J Epidemiol* 1988;2:255—62.
20. Spielberger CD. Theory and research on anxiety. In: Spielberger CD, ed. *Anxiety and behavior*. New York, NY: Academic, 1966.
21. Theorell T, Hjemdahl P, Ericsson F, et al. Psychosocial and physiological factors in relation to blood pressure at rest — a study of Swedish men in their upper twenties. *J Hypertens* 1985;3:591—600.