Original article

Scand J Work Environ Health. 2018;44(6):601–612. doi:10.5271/sjweh.3755

Association between demand–control model components and blood pressure in the ELSA-Brasil study: exploring heterogeneity using quantile regression analyses

by Leidjaira Lopes Juvanhol, PhD,[1] Enirtes Caetano Prates Melo, PhD,[2] Dóra Chor, PhD,[2] Maria de Jesus Mendes da Fonseca, PhD,[2] Lúcia Rotenberg, PhD,[3] Leonardo Soares Bastos, PhD,[4] José Geraldo Mill, PhD,[5] Rosane Härter Griep, PhD [3]

Juvanhol LL, Melo ECP, Chor D, Fonseca MJM, Rotenberg L, Bastos LS, Mill JG, Griep RH. Association between demand–control model components and blood pressure in the ELSA-Brasil study: exploring heterogeneity using quantile regression analyses. *Scand J Work Environ Health*;44(6):601–612. doi:10.5271/sjweh.3755

Objectives This study aimed to investigate which components of the demand–control model (DCM) are associated with blood pressure (BP) and ascertain whether these associations vary over the BP distribution.

Methods We evaluated the baseline date of 11 647 current workers enrolled in the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) (2008–2010), a multicenter cohort study of 35–74-year-old civil servants. Job demands, skill discretion and decision authority were measured using the Brazilian version of the Demand–Control–Support Questionnaire. The associations between DCM components and systolic and diastolic BP (SBP and DBP, respectively) were examined by gamma regression, indicated for modelling skewed continuous variables, and quantile regression. Tests were conducted for interaction with gender and use of antihypertensives.

Results In the adjusted gamma models, no association was observed between DCM components and BP in the total study population. Among non-users of antihypertensives, high decision authority was marginally associated with an increase of 0.59 mmHg (95% CI 0.00–1.18) in SBP. In the quantile models, this association was found to be significant from quantiles 35–60. Further significant but inconsistent positive associations were observed between decision authority and DBP among users of antihypertensives (quantiles 5 and 10) and between skill discretion and SBP in the total study population (quantile 5). The results did not differ by gender.

Conclusions Decision authority associates positively with SBP, but only in the central portion of the SBP distribution and among non-users of antihypertensives. No consistent associations were observed for skill discretion or job demands.

Key terms hypertension; job control; job demand; job strain; job stress; Karasek; psychological stress.

High blood pressure levels are the main risk factor for the global burden of disease and were responsible for some 10.4 million deaths worldwide in 2013 (1). There is evidence that, from 115 mmHg systolic blood pressure (SBP) and 75 mmHg diastolic blood pressure (DBP), cardiovascular risk increases steadily and linearly (2). The relation between blood pressure and cardiovascular outcomes is thus continuous and direct, but the lower boundary, below which no gain results from reducing blood pressure levels, is still uncertain (3).

Although blood pressure is a continuously distributed cardiovascular risk factor, studies of its determinants have focused on the central portion or the extremes of the distribution, using conventional regression methods that estimate effects for the population mean or that model high blood pressure as a dependent variable (4–6). These analytical strategies are very useful, but they do not permit an understanding of how such determinants affect the whole blood pressure distribution. Accordingly, important aspects of the association studied can remain hidden. Quantile regression is an alternative technique by which the effects of exposure

1 Department of Nutrition and Health, Federal University of Viçosa, Viçosa, Minas Gerais, Brazil.
2 National School of Public Health, Oswaldo Cruz Foundation, Rio de Janeiro, Rio de Janeiro, Brazil.
3 Laboratory of Health and Environment Education, Oswaldo Cruz Institute, Oswaldo Cruz Foundation, Rio de Janeiro, Rio de Janeiro, Brazil.
4 Scientific Computing Program, Oswaldo Cruz Foundation, Rio de Janeiro, Rio de Janeiro, Brazil.
5 Department of Physiological Sciences, Federal University of Espírito Santo, Vitória, Espírito Santo, Brazil.

Correspondence to: Rosane Härter Griep, PhD, Laboratory of Health and Environment Education, Oswaldo Cruz Institute, Oswaldo Cruz Foundation, Rio de Janeiro, Brazil. [E-mail: rohgriep@ioc.fiocruz.br].

can be estimated in different quantiles of the outcome distribution (7), but it is rarely used in epidemiology (8). One study using this method to examine some of the factors most related to blood pressure, including age, body mass index and physical activity, revealed the existence of heterogeneous patterns of association across the blood pressure distribution (9). In that light, efforts are needed to improve the understanding of how other important determinants act on the blood pressure continuum.

Of the various factors that determine increased blood pressure levels, major emphasis has been placed on the role of psychosocial variables, including workplace stressors (10). Job strain has become an important field of research in recent decades and a number of theoretical models have been proposed for evaluating its health effects. The most widely known of these, the demand–control model (DCM) developed by Karasek, defines job strain as the product of a combination of high demands and low control over the work process (11). Job demands relate to the load and pace of activities and the difficulty of performing them, as well as the presence of contradictory requirements. Job control comprises two subscales: skill discretion and decision authority, the former relating to opportunities to be creative, use intellectual competences and lean new things; the latter, to the authority to take decisions on how to work (12).

As there is no consensus on the best approach to evaluating DCM, job strain has been operationalized in different ways (13, 14). The strategy most commonly adopted is a classification by quadrants (15), where the dimensions are dichotomized at their medians and job strain is defined as the combination between high job demands and low job control (11). Other procedures often used include independent evaluation of the dimensions and using ratios (16) or subtractions (14) between levels of job demands and job control. One aspect common to all these approaches has drawn criticism: the analyses merge the two subscales of the job control dimension, disregarding the fact that they represent theoretically distinct constructs (17). There is evidence that skill discretion and decision authority can exert opposing effects on different health outcomes (18–21). Also, psychometric analyses of the main instruments used to gauge DCM have shown that these subscales do in fact form two distinct dimensions (17, 22–24).

Despite the positive evidence of an association between job strain and blood pressure (25–27), a growing number of studies have also produced inconclusive results (28–31). The possible explanations proposed for these divergences relate mostly to methodological issues, including: study design (cross-sectional versus longitudinal studies), study population (general population versus specific occupation), method of measuring blood pressure (casual versus ambulatory), the instrument used to measure the DCM, how the exposure and outcome measurements are operationalized, and adjustment for potential confounders (26, 27, 32–34). Also, from the foregoing, two potential sources of inconsistencies as yet little explored in prior studies have been identified: analysis of the job control dimension subscales as a single construct and the use of analytical strategies that yield evidence on specific portions of the blood pressure distribution.

In addition to methodological considerations, the divergences among the studies can be ascribed partly to the fact that the effects of job strain are not homogeneous in the population. In that regard, various factors have been noted to act on moderate individual susceptibility to the harmful effects of job strain (35, 36). Prominent among these are gender-related factors, as less consistent results for the association between job strain and blood pressure have been observed among women (26, 33). Another important, and as yet little explored, factor is use of antihypertensives. Although practically all studies of the relation between job strain and blood pressure consider such use a confounder (37, 38) or exclude medicated hypertensives from their analyses (39, 40), it has been demonstrated that the relations between a number of factors and blood pressure vary between users and non-users of antihypertensives (9, 34, 41). Accordingly, it is suggested that antihypertensives are potentially effect modifiers of the association studied here (37, 38).

Given these observations, the aims of this study were to: (i) investigate whether the individual DCM components, especially skill discretion and decision authority, are associated differently with blood pressure; and (ii) using quantile regression, examine whether these associations vary over the blood pressure distribution. We also tested for the presence of interaction with gender and use of antihypertensive drugs.

Methods

Study population

The Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) is a multicenter cohort study whose baseline included 15 105 current and retired civil servants of both genders, 35–74 years old, from higher education and research institutions in six of Brazil's state capitals (the federal universities of Minas Gerais, Espírito Santo, Bahia and Rio Grande do Sul, the University of São Paulo and the Oswaldo Cruz Foundation). Volunteers were recruited through communication strategies (on-site and radio announcements, mailings, outdoor billboards and telephone calls) and active recruitment (from a randomly ordered list of employees). Efforts were made to meet recruitment goals by gender, age, and occupational category so as to ensure a wide demo-

graphic and socioeconomic gradient across the study population. Detailed descriptions of the study design and recruitment methods can be found in other publications (42–44). The research ethics committees of each of the participating institutions and the national research ethics committee (CONEP – No. 13065) approved the ELSA-Brasil research protocol. Informed consent was obtained from all study participants.

This study used ELSA-Brasil baseline data (2008–2010), which were collected by interview and clinical and laboratory examinations conducted to rigorous standards of quality assurance and control (45). The analyses in this article excluded the retired participants (N=3009) and those with missing data on the study variables (N=449), resulting in a study sample of 11 647 participants.

Variables

Blood pressure and use of antihypertensive drugs. Blood pressure was measured during the morning in a quiet room at a controlled temperature (20–24 °C). With the participant in a seated position, with an empty bladder and after resting for five minutes, three measurements were taken on the left arm at one-minute intervals, using a validated oscillometric blood pressure monitor (Omron HEM 705CPINT). Blood pressure was considered to be the mean of the last two measurements (46).

Participants were asked about any continuous drug use in the two weeks prior to the baseline examination and antihypertensive drugs were characterized according to their pharmacological classification. In this study, users of antihypertensives were considered to be those who, in addition to reporting using an antihypertensive drug, answered affirmatively to the question: "Was any of the drugs you have taken during the past two weeks for hypertension (high blood pressure)?".

DCM components. The Brazilian version (47) of the Swedish Demand–Control–Support Questionnaire (DCSQ) (16) was used to measure levels of job demands (5 items), skill discretion (4 items) and decision authority (2 items). Each item comprised four response categories, ranging from "often" to "never or hardly ever". The Brazilian version of the DCSQ demonstrated satisfactory reproducibility and internal consistency (47). In keeping with the findings of studies that have evaluated the dimensional structure of this instrument (23, 24), the item on repetitive work was removed from the skill discretion scale. In constructing the indicators for each DCM component, the scores produced by adding together the responses to the items on job demands (5–20 points), skill discretion (3–12 points) and decision authority (2–8 points) were dichotomized into high and low at the median for these dimensions (14, 11, and 6 points, respectively).

Potential confounding factors. Potential confounders of the association between job strain and blood pressure have been identified in the literature. As a guide in selecting covariables for inclusion in the analyses, a directed acyclic graph (DAG) was constructed using the DAGitty programme (48). This approach has been used in epidemiology to represent causal relations among variables and assists in identifying a minimum set of covariables that is sufficient to control for the confounder situation (49).

On the basis of this strategy, the following covariables were considered in this study: gender (male and female); age (continuous, in years); race/color, self-reported by the classification used in Brazil's population census (black, brown, white, Asian, or indigenous); schooling, as a marker of present socioeconomic position (up to lower secondary complete, upper secondary complete, undergraduate incomplete, undergraduate complete and postgraduate); mother's schooling, as a marker of early socioeconomic position (less than lower secondary complete, lower secondary complete, upper secondary complete and undergraduate complete); weekly hours worked (continuous, in hours) and recruitment site (Bahia, Espírito Santo, Minas Gerais, Rio de Janeiro, Rio Grande do Sul or São Paulo). Unhealthy lifestyle-related variables (poor diet, sedentarism and alcohol and tobacco use), obesity and type-2 diabetes were not considered confounders, because they have been indicated to be mediators of the association studied here (33, 50). In the same way, family history of cardiovascular diseases was not considered a confounder, because there is no evidence to support an association with job strain.

Statistical analyses

Tests of means (T-test and ANOVA for covariables with two or more categories, respectively) and proportions (chi-square) were used to compare blood pressure levels and DCM component frequencies by covariable.

The associations between the exposure variables (job demands, skill discretion and decision authority) and outcomes (SBP and DBP) were first tested using gamma regression models. These models belong to the class of generalized linear models and are appropriate for strictly positive, asymmetrical, continuous outcomes, as is the case with blood pressure (51). Although the ordinary least squares (OLS) method is widely used to model blood pressure as a continuous variable, prior studies have indicated a better fit from the gamma model using a dependent variable with similar distributional characteristics (52, 53). In the gamma models, the identity link function was chosen because it permits direct interpretation of the estimated parameters (51). Thus, our results can be directly compared with those of previous studies on the topic that have used the OLS method.

From the set of covariables mentioned above, four

models were constructed for each DCM component, considering SBP and DBP separately: (i) crude model; (ii) model adjusted for gender, age and recruitment site; (iii) model 2 with additional adjustment for race/color and markers of socioeconomic position; and (iv) model 3 with additional adjustment for weekly hours worked. An interaction term was included in the final models (model 4) in order to test for the presence of interaction between each DCM component and the variables "gender" and "use of antihypertensives".

In order to test for heterogeneity in the association between exposure and outcome over the blood pressure distribution, quantile regression models were also fitted (7). The quantile models were constructed for each DCM component, considering SBP and DBP separately. Coefficients were estimated at regular 5-quantile intervals, from the 5th to the 95th quantile and were adjusted for the covariables present in the final gamma model (model 4).

In all the analyses, the coefficients of the gamma and quantile models represent the difference in blood pressure, in mmHg, for the categories "high job demands", "high skill discretion" and "high decision authority" in comparison with the reference categories (respectively, "low job demands", "low skill discretion" and "low decision authority"). All analyses were performed using R 3.1.2 (54). The quantreg library (55) was applied to fit the quantile regression models, while the graphs were drawn using ggplot2 (56).

Results

Participant characteristics

In the overall study population, mean SBP was 119.5 mmHg (1st quartile [Q1]=108; median [Q2]=117.5; 3rd quartile [Q3]=128.5) and mean DBP was 76.3 mmHg

Table 1. Characterization of participants by blood pressure levels and demand–control model components. ELSA-Brasil, 2008–2010 (N=11647) [DBP=diastolic blood pressure; SBP=systolic blood pressure].

Variables	N	%	Mean (mmHg)		Frequency (%)		
			SBP	DBP	High job demands	High skill discretion	High decision authority
Gender							
Male	5523	47.4	124.3 [b]	79.1 [b]	46.1 [b]	63.6 [b]	62.6 [b]
Female	6124	52.6	115.3	73.8	54.3	60.8	57.8
Age (years) [a]							
35–44	3265	28.0	114.6 [b]	74.2 [b]	53.1 [b]	63.8 [b]	58.1 [b]
45–54	5568	47.8	119.7	76.9	51.0	60.3	59.2
55–64	2580	22.2	124.5	77.6	47.0	63.7	63.8
65–74ß	234	2.0	131.3	77.7	35.9	66.7	67.9
Race/color							
Black	1879	16.1	124.6 [b]	79.1 [b]	48.8 [c]	52.7 [b]	51.9 [b]
Brown	3374	29.0	121.3	77.4	49.9	56.5	53.5
White	5993	51.5	117.0	74.9	51.2	68.3	66.1
Asian	283	2.4	117.1	73.9	54.8	69.3	71.4
Indigenous	118	1.0	124.6	77.2	41.5	42.4	45.8
Schooling							
Up to lower secondary complete	1199	10.3	128.4 [b]	80.1 [b]	38.5 [b]	34.6 [b]	43.8 [b]
Upper secondary complete	3339	28.7	121.9	77.5	46.5	46.2	46.1
Undergraduate incomplete	889	7.6	119.4	77.0	51.3	54.1	53.3
Undergraduate complete	1896	16.3	117.6	75.4	49.1	59.3	57.5
Postgraduate	4324	37.1	116.2	74.5	57.1	84.9	77.9
Mother's schooling							
Less than lower secondary complete	6483	55.7	121.0 [b]	77.0 [b]	47.5 [b]	54.4 [b]	53.2 [b]
Lower secondary complete	2280	19.6	119.0	75.9	52.5	65.3	62.9
Upper secondary complete	2051	17.6	117.4	75.5	54.3	74.3	71.8
Undergraduate complete	833	7.2	114.8	73.6	57.7	83.8	77.1
Working week (hours) [a]							
<40	2042	7.2	121.5 [b]	76.7 [b]	43.7 [b]	50.0 [b]	49.2 [b]
40	5759	49.4	119.9	76.6	43.0	56.4	58.9
>40	3846	33.0	118.0	75.7	65.1	77.2	67.6
Recruitment site							
Bahia	1453	12.5	124.7 [b]	78.9 [b]	47.2 [b]	58.9 [b]	57.9 [b]
Espírito Santo	810	7.0	117.9	74.3	53.8	57.9	59.3
Minas Gerais	2389	20.5	119.4	77.1	54.9	64.7	58.4
Rio de Janeiro	1589	13.6	118.6	76.9	48.6	72.7	65.3
Rio Grande do Sul	1445	12.4	119.2	75.6	49.0	59.8	59.7
São Paulo	3961	34.0	118.5	75.2	49.4	59.3	60.1

[a] Variables categorized for the descriptive analysis only.
[b] P<0.01 in the means comparison test for SBP and DBP or in the chi-square test for the demand–control model components.
[c] P<0.05 in the means comparison test for SBP and DBP or in the chi-square test for the demand–control model components.

(Q1=68.5; Q2=75.5; Q3=83) (see supplementary file 1 for sample quantiles of the blood pressure distribution, www.sjweh.fi/show_abstract.php?abstract_id=3755). Of total participants, 50.4% (N=5871) were classified as under high job demands, 62.1% (N=7237) as high skill discretion and 60.1% (N=6998) as enjoying high decision authority. Table 1 shows the descriptive characteristics of the study population, which comprised 5523 men and 6124 women, including mostly participants who were 45–54 years old (47.8%), white (51.5%), postgraduates (37.1%), whose mothers were educated to less than complete lower secondary level (55.7%) and who worked a 40-hour week (49.4%).

Higher SBP and DBP levels were observed in men, those who were older, who declared themselves to be black or indigenous, had less schooling, had mothers with less schooling and who worked a shorter week. As regards the DCM components, the highest frequency of high job demands was observed among women and the younger participants, while higher levels of skill discretion and decision authority were observed among men and the older participants. Participants of white and Asian race/color, those with more schooling, those whose mothers had more schooling and those with longer working weeks reported higher levels of the three components examined. The "recruitment site" variable returned significantly higher blood pressure levels among participants from Bahia state. A higher frequency of high job demands was observed in the states of Espírito Santo and Minas Gerais, while high skill discretion and high decision authority were more frequent in Rio de Janeiro (table 1).

Association between the DCM components and blood pressure in the gamma models

In the overall study population, job demands, skill discretion and decision authority were inversely associated with SBP and DBP in the unadjusted gamma regression models. After adjusting for confounders, however, no significant association was observed. The coefficients estimated were similar by gender (P for interaction test >0.05), but use of antihypertensives and decision authority were observed to interact significantly in relation to SBP (table 2).

In analyses stratified by use of antihypertensives (table 3), a borderline positive association was observed between decision authority and SBP only among participants who were non-users of antihypertensives, where SBP increased by 0.59 mmHg (95% CI 0.00–1.18) among those with high decision authority. Nor was interaction with gender significant in the models stratified by use of antihypertensives.

Association between DCM components and blood pressure in the quantile models

Total study population results from the quantile models are shown in figure 1. No association was observed with job demands or decision authority anywhere in the distribution of either of the outcomes examined. In relation to the skill discretion component, a positive association was found only with SBP at the lower end of the distribution, with a coefficient of 1.01 mmHg (95% CI 0.31–1.71) in quantile 10.

Figure 2 shows the results from the quantile models for the association between decision authority and blood pressure, stratified by use of antihypertensives. Among non-users of antihypertensives, a positive association was observed in the central portion of the SBP distribution. The coefficients were significant from quantiles 35–60, the highest value being found at quantile 55, where high decision authority was associated with an

Table 2. Coefficients (95% CI) for the association between the demand–control model components and blood pressure in the gamma regression models for the total study population. ELSA-Brasil, 2008-2010 (N=11 647) [CI=confidence interval; Coef=coefficient; DBP=diastolic blood pressure; SBP=systolic blood pressure].

Models	SBP (mmHg)						DBP (mmHg)					
	High job demands [e]		High skill discretion [f]		High decision authority [g]		High job demands [e]		High skill discretion [f]		High decision authority [g]	
	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI
Model 1 [a]	-2.06	-2.66–-1.47	-2.00	-2.62–-1.39	-1.02	-1.63–-0.42	-1.15	-1.55–-0.76	-0.93	-1.34–-0.53	-0.71	-1.11–-0.31
Model 2 [b]	-0.88	-1.43–-0.34	-2.07	-2.64–-1.51	-1.69	-2.25–-1.14	-0.60	-0.98–-0.22	-1.17	-1.55–-0.78	-1.06	-1.44–-0.68
Model 3 [c]	-0.26	-0.79–0.27	0.37	-0.22–0.96	0.25	-0.31–0.82	-0.24	-0.61–0.13	0.22	-0.19–0.63	0.03	-0.36–0.43
Model 4 [d]	-0.11	-0.65–0.43	0.47	-0.12–1.07	0.27	-0.29–0.84	-0.20	-0.57–0.18	0.26	-0.15–0.67	0.04	-0.35–0.43
P for interaction with gender		0.14		0.74		0.72		0.12		0.48		0.56
P forinteraction with use of antihypertensives		0.36		0.31		0.02		0.66		0.84		0.69

[a] Crude model.
[b] Model adjusted for gender, age and recruitment site.
[c] Model 2 + race/color, schooling and mother's schooling.
[d] Model 3 + weekly hours worked.
[e] Reference category: low job demands.
[f] Reference category: low skill discretion.
[g] Reference category: low decision authority.

increase of 0.94 mmHg (95% CI 0.22–1.66) in SBP. Among users of antihypertensives, in turn, a direct association was observed only at the lower end of the DBP distribution, where the coefficients were 1.85 mmHg (95% CI 0.48–3.22) and 1.32 mmHg (95% CI 0.28–2.36) in quantiles 5 and 10, respectively.

For details on quantile regression coefficients and 95% CI, see supplementary files 2 and 3, www.sjweh.fi/show_abstract.php?abstract_id=3755.

Table 3. Coefficients (95% CI) for the association between decision authority and blood pressure in the gamma regression models, by use of antihypertensives. ELSA-Brasil, 2008-2010 [CI=confidence interval; Coef=coefficient; DBP=diastolic blood pressure; SBP=systolic blood pressure].

Models	SBP (mmHg)		DBP (mmHg)	
	High decision authority [e]		High decision authority [e]	
	Coef.	95% CI	Coef.	95% CI
Non-users of antihypertensives (N=9057)				
Model 1 [a]	-0.30	-0.94–0.34	-0.44	-0.88–0.00
Model 2 [b]	-1.08	-1.66–-0.50	-0.86	-1.28–-0.45
Model 3 [c]	0.57	-0.02–1.17	0.10	-0.32–0.53
Model 4 [d]	0.59	0.00–1.18	0.11	-0.32–0.53
P for interaction with gender		0.78		0.90
Users of antihypertensives (N=2590)				
Model 1 [a]	-1.99	-3.37–-0.61	-0.76	-1.61–0.09
Model 2 [b]	-2.34	-3.68–-1.00	-0.65	-1.48–0.18
Model 3 [c]	-0.24	-1.60–1.12	0.26	-0.60–1.12
Model 4 [d]	-0.19	-1.55–1.17	0.28	-0.58–1.14
P for interaction with gender		0.91		0.35

[a] Crude model.
[b] Model adjusted for gender, age and recruitment site.
[c] Model 2 + race/color, schooling and mother's schooling.
[d] Model 3 + weekly hours worked.
[e] Reference category: low decision authority.

Discussion

Our main results indicated that high decision authority associates positively with SBP and that this association occurs only in the central portion of the blood pressure distribution and among non-users of antihypertensives. No consistent associations were observed for decision authority and DBP or for skill discretion and SBP/DBP. Moreover, no significant association was observed for job demands. This is the first study to investigate the association between job strain and blood pressure using quantile regression analysis. To date, we have been unable to identify any publication that has compared the two components of the job control dimension in studying this relationship.

Independently of the analytical strategy applied, our analyses detected no association between job demands and blood pressure. Although the DCM originally proposed that excessive job demands act adversely on cardiovascular health (57), other authors have also failed to identify significant associations between this dimension and blood pressure levels (28, 58) and with others cardiovascular risk factors (21, 59). It has been suggested that these inconsistencies can be explained, at least in part, by non-differential information bias, given that the concept of job demands measured by the DCM does not properly capture emotional demands. Thus, the actual level of job demands that workers are exposed to is being underestimated, which consequently leads to underestimation of the true association between this dimension and blood pressure (33).

High decision authority at work, on the other hand, was found to associate with higher blood pressure, con-

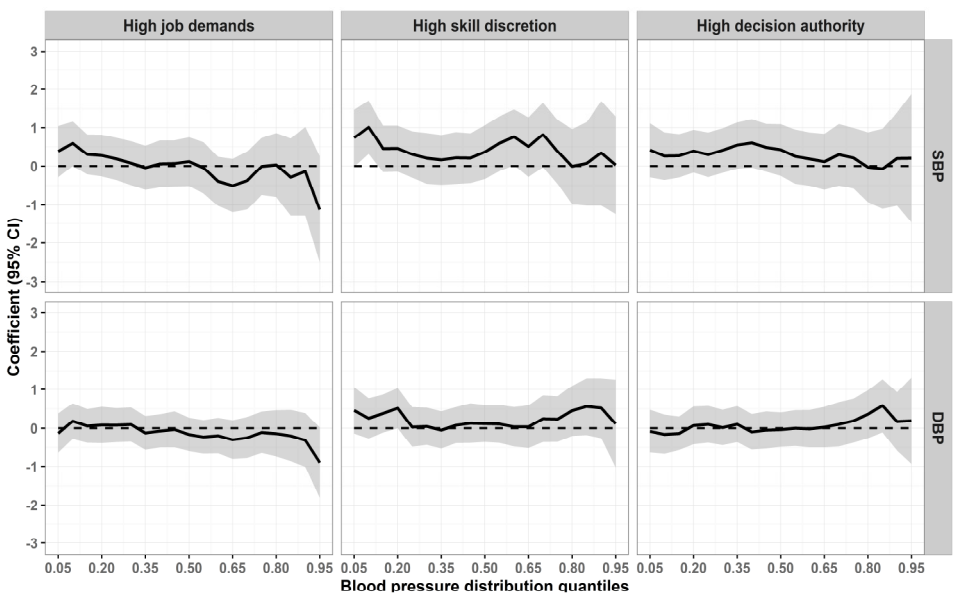

Figure 1. Coefficients (95% CI) for the association between demand–control model components and blood pressure in the quantile regression models for the total study population. ELSA-Brasil, 2008-2010. The solid lines and adjacent shaded areas represent, respectively, the estimates and their 95% confidence interval (CI). The broken lines indicate the null value. The coefficients are adjusted by gender, age, recruitment site, race/color, schooling, mother's schooling and weekly hours worked. [DBP=diastolic blood pressure; SBP=systolic blood pressure.]

trary to the effects proposed by the DCM (57). In agreement with the results of this study, Joensuu et al (20), in a cohort of 13 510 employees of a Finnish company, identified greater overall mortality and specific mortality by cardiovascular outcomes and causes related to alcohol consumption among those with higher levels of decision authority. Previous results in the same cohort indicated that greater decision authority was associated with increased risk of hospital admission for mental disorders, including those relating to alcohol use and depression (19). Similarly, other authors have found that decision authority is positively associated with overall and central obesity as measured, respectively, by body mass index and waist circumference (21).

In recent years, changes in how work is organized – especially as regards increasingly long workhours, the prevalence of occupations requiring intense computer use and higher qualifications and the declining number of manual workers – point to a need to reconsider certain aspects of the DCM (60). In this new context, the health benefits of increasing decision authority may not be as evident as in the historical context where the DCM was developed (11), which was characteristically one of industrialization and repetitive tasks (61).

In the contemporary world of work, although the opportunity to take decisions about one's own work has directly impacted productivity (62), excessive decision authority resulting from the growing need for job flexibility can be seen as a source of stress. The growing burden of responsibilities and decisions may reach overload, especially when workers are not given the necessary resources (20, 61, 63). Also, high degrees of decision authority at work may lead to negative feelings resulting from the number of decisions to be taken and the uncertainties involved in making those choices (21, 64). However, more studies are needed to confirm these hypotheses, among other things to consider the possible influence of structural and contextual determinants on psychosocial aspects of work (65).

Also, and again contrary to the effects proposed by the theory of Karasek & Theorell (57) and found by other authors as regards different outcomes (20, 21, 59), we observed a positive association between skill discretion and SBP in the quantile model estimated for the total study population. However, we insist that it should be interpreted with great caution because it was significant in only one outer quantile of the distribution (quantile 10). On this point, it has been shown that, in quantile regression models, estimation for outer quantiles (lower or upper) is prone to major instability because there is generally considerable data dispersion at these extremes (66). The same care should be taken in interpreting the positive association observed between decision authority and DBP among antihypertensive users as the coefficients were significant for quantiles 5 and 10 only.

On the other hand, more consistent results were found in the quantile regression models for the association between decision authority and SBP for non-users of antihypertensives, where significant coefficients were observed from quantiles 35–60. Investigation of the relationship between different factors and blood pressure using quantile regression found a similar pattern for the association between stressful life-course events and SBP: higher coefficients were observed in the central portion of the distribution among participants who were non-users of antihypertensives (9). As with our findings, a study of Japanese workers found no overall

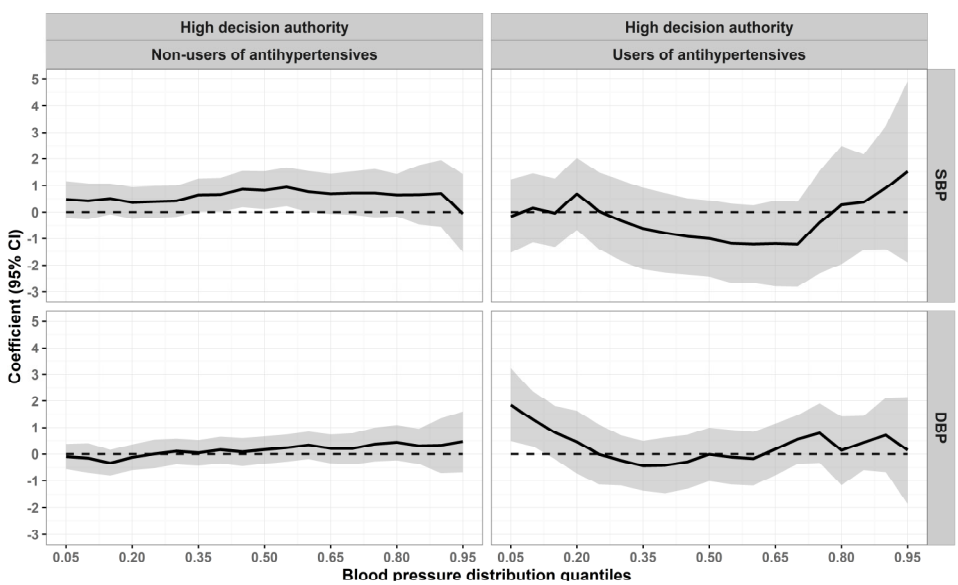

Figure 2. Coefficients (95% CI) for the association between decision authority and blood pressure in the quantile regression models, by use of antihypertensives. ELSA-Brasil, 2008-2010. The solid lines and adjacent shaded areas represent, respectively, the estimates and their 95% confidence intervals (CI). The broken lines indicate the null value. The coefficients are adjusted by gender, age, recruitment site, race/color, schooling, mother's schooling and weekly hours worked. Reference category: low skill discretion. [DBP=diastolic blood pressure; SBP=systolic blood pressure.]

association between job control and blood pressure, but significant results were observed among subjects with moderately high blood pressure (130≥SBP<160 mmHg and 85≥SBP<100) (67). That study, however, found an inverse association, but assessed job control as a single dimension. Another study also found no association between job strain quadrants and blood pressure for the overall study population, but it did identify significant results in a subgroup of previously normotensive subjects with high SBP in the workplace (68).

In this latter respect, Landsbergis et al (32) suggested that job strain first raises blood pressure levels in the workplace, without alterations being detected in casual blood pressure. Increased casual blood pressure is thought to occur only at later stages, when chronic exposure to these stressors has produced structural modifications to the cardiovascular system (36, 69, 70), particularly by remodeling minor arteries and arterioles which are the primary site of total peripheral resistance (71).

Accordingly, in our results, the small increase in SBP associated with high decision authority that was observed among those with blood pressure levels within normal limits (in the most central portion of the distribution) may reflect the presence of more pronounced alterations in blood pressure in the workplace. Future studies using ambulatory blood pressure monitoring will be able to provide additional evidence to help understand these findings.

Despite evidence of gender differences in the relationship between job strain and blood pressure (26, 33), this study did not identify any interaction between gender and the DCM components examined. It is suggested that this finding may be attributed partly to the specific characteristics of the ELSA-Brasil study population, which comprised civil servants, which may be confirmed by future studies using longitudinal cohort data. Meanwhile, the results of this study show that antihypertensives act as a considerable moderator of the relationship examined here, given that the more consistent associations were observed among non-users of these drugs. Antihypertensives act by reducing blood pressure artificially, while the blood pressure levels of individuals who use antihypertensives result from the combined action of a variety of factors, including proper prescribing by health professionals, the individuals' adhering to drug therapy, modifications in lifestyle and the presence of comorbidities including obesity and diabetes (72–74). Accordingly, the interaction among all these factors may make the study of the relationship between blood pressure and its determinants more complex among users of antihypertensives.

As regards the analyses stratified by use of antihypertensives, we would like to emphasize that blood pressure levels were higher among users than non-users of these drugs, as can be seen in supplementary file 1. Non-users of antihypertensives are mostly normotensive subjects (about 90% in our study population; data not shown), and, accordingly, are expected to display lower SBP and DBP. Also, despite the high proportion of hypertensive participants with blood pressure control in the ELSA-Brasil study, around 30% of users of antihypertensives did not control their blood pressure (75).

Using DAG as a strategy to assist in selecting potential confounders of the relation studied was a strength of this study. Although constructed on the basis of a deduced causal structure between the variables examined, this approach does help to estimate less biased measures of effect (76). On this point, insufficient control for potential confounders has been indicated as one of the main sources of inconsistencies among studies of job strain and blood pressure (33). This study thus used a broad set of covariables and also considered mother's schooling as a marker of early socioeconomic position, because it has been shown that the relationship between aspects of work and cardiovascular risk factors can be partly confounded by social disadvantages that originate in earlier stages of life (77). In our analyses, we observed that adjusting for potential confounders affected the gamma model coefficients considerably, generally resulting in loss of statistical significance. Notably, the direction of the association between the two job control components and blood pressure was observed to reverse after adjustment for the indicators of socioeconomic position. In our study population, the levels of DCM components, especially skill discretion and decision authority, were directly associated with socioeconomic position, while socioeconomic position associated inversely with blood pressure. Accordingly, socioeconomic position seems to act as a qualitative confounder in the association between the two job control components and blood pressure (78).

A strength of this study includes the use of data collected with extreme methodological rigor and relatively large sample size. Lastly, another strength of this study is its innovative analytical strategy, which combined independent assessment of the DCM components with statistical techniques suited to the nature of the data, yielded complementary evidence of the relationship studied here.

The limitations of the study include the cross-sectional nature of the analyses, which limits interpretations of the direction of the associations observed, while the possibility of reverse causality cannot be discarded. However, as the condition is asymptomatic, it is hardly plausible that increased blood pressure levels can modify the status of exposure to job strain. In studies such as ELSA-Brasil, volunteer recruitment is a potential source of selection bias, because participants and non-participants may differ systematically in relation to various characteristics (78). However, because of two

characteristics of the ELSA-Brasil study, we believe it unlikely that our results were influenced by such bias. Firstly, recruitment quotas guaranteed demographic and socioeconomic variety in the study population. Secondly, the recruitment strategies used invited participation in a follow-up study, with no mention of any specific risk factor or disease. It is therefore unlikely for participants and non-participants to differ systematically as regards job strain and blood pressure, that is, that there be any distortion of exposure-outcome association.

The use of casual blood pressure measurement is another limitation, because as already mentioned it does not measure alterations in blood pressure at important points in the day, such as at work or during sleep, and measurements are liable to the "white coat effect". Lastly, the study population displayed high levels of skill discretion and decision authority (medians of 11 and 6 points, respectively) and as a result, less heterogeneity in scores in these subscales. On this point, it has been pointed out that, in samples that are occupationally homogeneous (as with this study sample made up of civil servants), levels of the DCM dimensions are also more similar, which can lead to an underestimation of measures of association (33). It is thus possible that, as our sample was less heterogeneous in levels of skill discretion and decision authority, this may have led to underestimation of the association between these subscales and blood pressure.

In conclusion, our main findings showed that high decision authority and SBP are positively associated and that this association varies over the blood pressure distribution and by use of antihypertensives: significant coefficients were observed only in the central portion of the SBP distribution and only among non-users of antihypertensives. On the other hand, no consistent associations were found for decision authority in relation to DBP or for skill discretion in relation to either SBP or DBP. Moreover, no significant association was observed for job demands. The various analytical strategies applied in this study yield new evidence of the relationship between job strain and blood pressure. It is to be stressed that further studies are needed to evaluate the possibility of differential effects of the DCM components and to consider not only specific parts, but the whole continuum of blood pressure.

Acknowledgments

The ELSA-Brasil baseline study was supported by the Science and Technology Department of Brazil's Ministry of Health and by the Ministry of Science and Technology (the Brazilian Innovation Agency-FINEP and the National Research Council-CNPq) (grants 01 06 0010.00 RS, 01 06 0212.00 BA, 01 06 0300.00 ES, 01 06 0278.00 MG, 01 06 0115.00 SP, 01 06 0071.00 RJ). The first author held scholarships from the Carlos Chagas Filho Rio de Janeiro State Research Support Foundation (FAPERJ - E-26/200.226/2015). The funders had no role in study design, collection, analysis and interpretation of the data, writing of the report and decision to submit the paper for publication. The authors declare no conflicts of interest.

References

1. Forouzanfar MH, Alexander L, Anderson HR, Bachman VF, Biryukov S, Brauer M et al.; GBD 2013 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2015 Dec;386(10010):2287–323. http://dx.doi.org/10.1016/S0140-6736(15)00128-2

2. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R; Prospective Studies Collaboration. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet 2002 Dec;360(9349):1903–13. http://dx.doi.org/10.1016/S0140-6736(02)11911-8.

3. Chalmers J. "Treating hypertension" or "lowering blood pressure"? Extending the concept. Blood Press 2002;11(2):68–70. http://dx.doi.org/10.1080/blo.11.2.68.70.

4. Steffen M, Kuhle C, Hensrud D, Erwin PJ, Murad MH. The effect of coffee consumption on blood pressure and the development of hypertension: a systematic review and meta-analysis. J Hypertens 2012 Dec;30(12):2245–54. http://dx.doi.org/10.1097/HJH.0b013e3283588d73.

5. Grootveld LR, Van Valkengoed IG, Peters RJ, Ujcic-Voortman JK, Brewster LM, Stronks K et al. The role of body weight, fat distribution and weight change in ethnic differences in the 9-year incidence of hypertension. J Hypertens 2014 May;32(5):990–7. http://dx.doi.org/10.1097/HJH.0000000000000135.

6. Bosu WK. Determinants of Mean Blood Pressure and Hypertension among Workers in West Africa. Int J Hypertens. 2016;3192149.

7. Koenker R. Quantile Regression. New York: Cambridge University Press; 2005.

8. Beyerlein A. Quantile regression-opportunities and challenges from a user's perspective. Am J Epidemiol 2014 Aug;180(3):330–1. http://dx.doi.org/10.1093/aje/kwu178.

9. Shen X, Li K, Chen P, Feng R, Liang H, Tong G et al. Associations of blood pressure with common factors among left-behind farmers in rural China: a cross-sectional study using quantile regression analysis. Medicine (Baltimore) 2015 Jan;94(2):e142. http://dx.doi.org/10.1097/MD.0000000000000142.

10. Cuffee Y, Ogedegbe C, Williams NJ, Ogedegbe G, Schoenthaler A. Psychosocial risk factors for hypertension: an update of the literature. Curr Hypertens Rep 2014 Oct;16(10):483. http://dx.doi.org/10.1007/s11906-014-0483-3.

11. Karasek RA. Job Demands, job decision latitude, and mental strain: implications for job redesign. Adm Sci Q 1979;24(2):285–308. http://dx.doi.org/10.2307/2392498.

12. de Araújo TM, Karasek R. Validity and reliability of the job content questionnaire in formal and informal jobs in Brazil. SJWEH Suppl. 2008;(6):52–9.

13. Karasek R, Choi B, Ostergren PO, Ferrario M, De Smet P. Testing two methods to create comparable scale scores between the Job Content Questionnaire (JCQ) and JCQ-like questionnaires in the European JACE Study. Int J Behav Med 2007;14(4):189–201. http://dx.doi.org/10.1007/BF03002993.

14. Courvoisier DS, Perneger TV. Validation of alternative formulations of job strain. J Occup Health 2010;52(1):5–13. http://dx.doi.org/10.1539/joh.L9084

15. Alves MG, Hökerberg YH, Faerstein E. [Trends and diversity in the empirical use of Karasek's demand-control model (job strain): a systematic review]. Rev Bras Epidemiol 2013 Mar;16(1):125–36. http://dx.doi.org/10.1590/S1415-790X2013000100012.

16. Theorell T, Perski A, Akerstedt T, Sigala F, Ahlberg-Hultén G, Svensson J et al. Changes in job strain in relation to changes in physiological state. A longitudinal study. Scand J Work Environ Health 1988 Jun;14(3):189–96. http://dx.doi.org/10.5271/sjweh.1932.

17. Sanne B, Torp S, Mykletun A, Dahl AA. The Swedish Demand-Control-Support Questionnaire (DCSQ): factor structure, item analyses, and internal consistency in a large population. Scand J Public Health 2005;33(3):166–74. http://dx.doi.org/10.1080/14034940410019217.

18. de Jonge J, Reuvers MM, Houtman IL, Bongers PM, Kompier MA. Linear and nonlinear relations between psychosocial job characteristics, subjective outcomes, and sickness absence: baseline results from SMASH. Study on Musculoskeletal Disorders, Absenteeism, Stress, and Health. J Occup Health Psychol 2000 Apr;5(2):256–68. http://dx.doi.org/10.1037/1076-8998.5.2.256.

19. Joensuu M, Väänänen A, Koskinen A, Kivimäki M, Virtanen M, Vahtera J. Psychosocial work environment and hospital admissions due to mental disorders: a 15-year prospective study of industrial employees. J Affect Disord 2010 Jul;124(1-2):118–25. http://dx.doi.org/10.1016/j.jad.2009.10.025.

20. Joensuu M, Kivimäki M, Koskinen A, Kouvonen A, Pulkki-Råback L, Vahtera J et al. Differential associations of job control components with mortality: a cohort study, 1986-2005. Am J Epidemiol 2012 Apr;175(7):609–19. http://dx.doi.org/10.1093/aje/kws028.

21. Bean CG, Winefield HR, Sargent C, Hutchinson AD. Differential associations of job control components with both waist circumference and body mass index. Soc Sci Med 2015 Oct;143:1–8. http://dx.doi.org/10.1016/j.socscimed.2015.08.034.

22. Niedhammer I. Psychometric properties of the French version of the Karasek Job Content Questionnaire: a study of the scales of decision latitude, psychological demands, social support, and physical demands in the GAZEL cohort. Int Arch Occup Environ Health 2002 Mar;75(3):129–44. http://dx.doi.org/10.1007/s004200100270.

23. Griep RH, Rotenberg L, Vasconcellos AG, Landsbergis P, Comaru CM, Alves MG. The psychometric properties of demand-control and effort-reward imbalance scales among Brazilian nurses. Int Arch Occup Environ Health 2009 Nov;82(10):1163–72. http://dx.doi.org/10.1007/s00420-009-0460-3.

24. Hökerberg YH, Aguiar OB, Reichenheim M, Faerstein E, Valente JG, Fonseca MJ et al. Dimensional structure of the demand control support questionnaire: a Brazilian context. Int Arch Occup Environ Health 2010 Apr;83(4):407–16. http://dx.doi.org/10.1007/s00420-009-0488-4.

25. Markovitz JH, Matthews KA, Whooley M, Lewis CE, Greenlund KJ. Increases in job strain are associated with incident hypertension in the CARDIA Study. Ann Behav Med 2004 Aug;28(1):4–9. http://dx.doi.org/10.1207/s15324796abm2801_2.

26. Landsbergis PA, Dobson M, Koutsouras G, Schnall P. Job strain and ambulatory blood pressure: a meta-analysis and systematic review. Am J Public Health 2013 Mar;103(3):e61–71. http://dx.doi.org/10.2105/AJPH.2012.301153.

27. Babu GR, Jotheeswaran AT, Mahapatra T, Mahapatra S, Kumar A Sr, Detels R et al. Is hypertension associated with job strain? A meta-analysis of observational studies. Occup Environ Med 2014 Mar;71(3):220–7. http://dx.doi.org/10.1136/oemed-2013-101396.

28. Fornari C, Ferrario M, Menni C, Sega R, Facchetti R, Cesana GC. Biological consequences of stress: conflicting findings on the association between job strain and blood pressure. Ergonomics 2007 Nov;50(11):1717–26. http://dx.doi.org/10.1080/00140130701674208.

29. Kivimäki M, Head J, Ferrie JE, Shipley MJ, Steptoe A, Vahtera J et al. Hypertension is not the link between job strain and coronary heart disease in the Whitehall II study. Am J Hypertens 2007 Nov;20(11):1146–53.

30. Nyberg ST, Fransson EI, Heikkilä K, Alfredsson L, Casini A, Clays E et al.; IPD-Work Consortium. Job strain and cardiovascular disease risk factors: meta-analysis of individual-participant data from 47,000 men and women. PLoS One 2013 Jun;8(6):e67323. http://dx.doi.org/10.1371/journal.pone.0067323.

31. Chou LP, Tsai CC, Li CY, Hu SC. Prevalence of cardiovascular health and its relationship with job strain: a cross-sectional study in Taiwanese medical employees. BMJ Open 2016 Apr;6(4):e010467. http://dx.doi.org/10.1136/bmjopen-2015-010467.

32. Landsbergis PA, Schnall PL, Warren K, Pickering TG, Schwartz JE. Association between ambulatory blood pressure and alternative formulations of job strain. Scand J Work Environ Health 1994 Oct;20(5):349–63. http://dx.doi.org/10.5271/sjweh.1386.

33. Gilbert-Ouimet M, Trudel X, Brisson C, Milot A, Vézina M. Adverse effects of psychosocial work factors on blood pressure: systematic review of studies on demand-control-support and effort-reward imbalance models. Scand J Work Environ Health 2014 Mar;40(2):109–32. http://dx.doi.org/10.5271/sjweh.3390.

34. Juvanhol LL, Melo EC, Carvalho MS, Chor D, Mill JG, Griep RH. Job strain and casual blood pressure distribution: looking beyond the adjusted mean and taking gender, age, and use of antihypertensives into account. Results from ELSA-Brasil. Int J Environ Res Public Health 2017 Apr;14(4):451. http://dx.doi.org/10.3390/ijerph14040451.

35. Schwartz JE, Pickering TG, Landsbergis PA. Work-related stress and blood pressure: current theoretical models and considerations from a behavioral medicine perspective. J Occup Health Psychol 1996 Jul;1(3):287–310. http://dx.doi.org/10.1037/1076-8998.1.3.287.

36. Ohlin B, Berglund G, Rosvall M, Nilsson PM. Job strain in men, but not in women, predicts a significant rise in blood pressure after 6.5 years of follow-up. J Hypertens 2007 Mar;25(3):525–31. http://dx.doi.org/10.1097/HJH.0b013e32801220fa.

37. Steptoe A, Cropley M, Griffith J, Kirschbaum C. Job strain and anger expression predict early morning elevations in salivary cortisol. Psychosom Med 2000 Mar-Apr;62(2):286–92. http://dx.doi.org/10.1097/00006842-200003000-00022.

38. Trudel X, Brisson C, Milot A, Masse B, Vézina M. Psychosocial work environment and ambulatory blood pressure: independent and combined effect of demand-control and effort-reward imbalance models. Occup Environ Med 2013 Nov;70(11):815–22. http://dx.doi.org/10.1136/oemed-2013-101416.

39. Guimont C, Brisson C, Dagenais GR, Milot A, Vézina M, Mâsse B et al. Effects of job strain on blood pressure: a prospective study of male and female white-collar workers. Am J Public Health 2006 Aug;96(8):1436–43. http://dx.doi.org/10.2105/AJPH.2004.057679.

40. Gilbert-Ouimet M, Brisson C, Vézina M, Milot A, Blanchette C. Repeated exposure to effort-reward imbalance, increased blood pressure, and hypertension incidence among white-collar workers: effort-reward imbalance and blood pressure. J Psychosom Res 2012 Jan;72(1):26–32. http://dx.doi.org/10.1016/j.jpsychores.2011.07.002.

41. Ostir GV, Berges IM, Markides KS, Ottenbacher KJ. Hypertension in older adults and the role of positive emotions. Psychosom Med 2006 Sep-Oct;68(5):727–33. http://dx.doi.org/10.1097/01.psy.0000234028.93346.38.

42. Aquino EM, Barreto SM, Bensenor IM, Carvalho MS, Chor D, Duncan BB et al. Brazilian Longitudinal Study of Adult Health (ELSA-Brasil): objectives and design. Am J Epidemiol 2012 Feb;175(4):315–24. http://dx.doi.org/10.1093/aje/kwr294.

43. Aquino EM, Araujo MJ, Almeida MC, Conceição P, Andrade CR, Cade NV et al. [Participants recruitment in ELSA-Brasil (Brazilian Longitudinal Study for Adult Health)]. Rev Saude Publica 2013 Jun;47 Suppl 2:10–8. http://dx.doi.org/10.1590/S0034-8910.2013047003953.

44. Schmidt MI, Duncan BB, Mill JG, Lotufo PA, Chor D, Barreto SM et al. Cohort Profile: Longitudinal Study of Adult Health (ELSA-Brasil). Int J Epidemiol 2015 Feb;44(1):68–75. http://dx.doi.org/10.1093/ije/dyu027.

45. Schmidt MI, Griep RH, Passos VM, Luft VC, Goulart AC, Menezes GM et al. [Strategies and development of quality assurance and control in the ELSA-Brasil]. Rev Saude Publica 2013 Jun;47 Suppl 2:105–12. http://dx.doi.org/10.1590/S0034-8910.2013047003889.

46. Mill JG, Pinto K, Griep RH, Goulart A, Foppa M, Lotufo PA et al. [Medical assessments and measurements in ELSA-Brasil]. Rev Saude Publica 2013 Jun;47 Suppl 2:54–62. http://dx.doi.org/10.1590/S0034-8910.2013047003851.

47. Alves MG, Chor D, Faerstein E, Lopes CS, Werneck GL. [Short version of the "job stress scale": a Portuguese-language adaptation]. Rev Saude Publica 2004 Apr;38(2):164–71. http://dx.doi.org/10.1590/S0034-89102004000200003.

48. Textor J, Hardt J, Knüppel S. DAGitty: a graphical tool for analyzing causal diagrams. Epidemiology 2011 Sep;22(5):745. http://dx.doi.org/10.1097/EDE.0b013e318225c2be.

49. Greenland S, Pearl J, Robins JM. Causal diagrams for epidemiologic research. Epidemiology 1999 Jan;10(1):37–48. http://dx.doi.org/10.1097/00001648-199901000-00008.

50. Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. Work stress in the etiology of coronary heart disease--a meta-analysis. Scand J Work Environ Health 2006 Dec;32(6):431–42. http://dx.doi.org/10.5271/sjweh.1049.

51. McCullagh P, Nelder JA. Generalized Linear Models. 2nd ed. Boca Raton: Chapman and Hall/CRC; 1989.

52. Fonseca MJ, Andreozzi VL, Faerstein E, Chor D, Carvalho MS. Alternatives in modeling of body mass index as a continuous response variable and relevance of residual analysis. Cad Saude Publica 2008 Feb;24(2):473–8. http://dx.doi.org/10.1590/S0102-311X2008000200027.

53. Juvanhol LL, Lana RM, Cabrelli R, Bastos LS, Nobre AA, Rotenberg L et al. Factors associated with overweight: are the conclusions influenced by choice of the regression method? BMC Public Health 2016 Jul;16:642. http://dx.doi.org/10.1186/s12889-016-3340-2.

54. R Core Team. R: a language and environment for statistical computing. R Foundation for Statistical Computing; Vienna, Austria: 2016. Available from: https://www.R-project.org/.

55. Koenker R. Quantreg: quantile regression. R package version 5.29. Available from: https://CRAN.R-project.org/package=quantreg.

56. Wickham H. Ggplot2: elegant graphics for data analysis. New

York: Springer; 2009.

57. Karasek RA, Theorell T. Healthy Work: Stress, Productivity, and the Reconstruction of Working Life. New York: Basic Books; 1990.

58. Cesana G, Sega R, Ferrario M, Chiodini P, Corrao G, Mancia G. Job strain and blood pressure in employed men and women: a pooled analysis of four northern italian population samples. Psychosom Med 2003 Jul-Aug;65(4):558–63. http://dx.doi.org/10.1097/01.PSY.0000041473.03828.67.

59. Rocco PT, Bensenor IM, Griep RH, Moreno AB, Alencar AP, Lotufo PA et al. Job Strain and Cardiovascular Health Score (from the Brazilian Longitudinal Study of Adult Health [ELSA-Brasil] Baseline). Am J Cardiol 2017 Jul;120(2):207–12. http://dx.doi.org/10.1016/j.amjcard.2017.04.008.

60. Burr H, Bjorner JB, Kristensen TS, Tüchsen F, Bach E. Trends in the Danish work environment in 1990-2000 and their associations with labor-force changes. Scand J Work Environ Health 2003 Aug;29(4):270–9. http://dx.doi.org/10.5271/sjweh.731.

61. Joensuu M, Kivimäki M, Koskinen A, Kouvonen A, Pulkki-Råback L, Vahtera J et al. Response to invited commentary: joensuu et al. respond to "Structure and context matters". Am J Epidemiol 2012 Apr;175(7):625–6. http://dx.doi.org/10.1093/aje/kws024.

62. Griffin RW. Effects of work redesign on employee perceptions, attitudes, and behaviors: a long-term investigation. Acad Manage J 1991;34(2):425–35.

63. Joensuu M, Kivimäki M, Pentti J, Virtanen M, Väänänen A, Vahtera J. Components of job control and mortality: the Finnish Public Sector Study. Occup Environ Med 2014 Aug;71(8):536–42. http://dx.doi.org/10.1136/oemed-2014-102111.

64. Schwartz B. Self-determination. The tyranny of freedom. Am Psychol 2000 Jan;55(1):79–88. http://dx.doi.org/10.1037/0003-066X.55.1.79.

65. Rugulies R. Invited commentary: structure and context matters--the need to emphasize "social" in "psychosocial epidemiology". Am J Epidemiol 2012 Apr;175(7):620–4. http://dx.doi.org/10.1093/aje/kws033.

66. Wang HJ, Li D, He X. Estimation of High Conditional Quantiles for Heavy-Tailed Distributions. J Am Stat Assoc 2012;107(500):1453–64. http://dx.doi.org/10.1080/01621459.2012.716382.

67. Hattori T, Munakata M. Low job control is associated with higher diastolic blood pressure in men with mildly elevated blood pressure: the Rosai Karoshi study. Ind Health 2015;53(5):480–8. http://dx.doi.org/10.2486/indhealth.2014-0205.

68. Ducher M, Cerutti C, Chatellier G, Fauvel JP. Is high job strain associated with hypertension genesis? Am J Hypertens 2006 Jul;19(7):694–700. http://dx.doi.org/10.1016/j.amjhyper.2005.12.016.

69. Goldstein IB, Shapiro D, Chicz-DeMet A, Guthrie D. Ambulatory Blood Pressure, Heart Rate, and Neuroendocrine Responses in Women Nurses During Work and Off Work Days. Psychosom. Med. 1999;61(3):387–96.

70. Thomas KS, Nelesen RA, Ziegler MG, Bardwell WA, Dimsdale JE. Job strain, ethnicity, and sympathetic nervous system activity. Hypertension 2004 Dec;44(6):891–6. http://dx.doi.org/10.1161/01.HYP.0000148499.54730.0d.

71. Schiffrin EL. Remodeling of resistance arteries in essential hypertension and effects of antihypertensive treatment. Am J Hypertens 2004 Dec;17(12 Pt 1):1192–200. http://dx.doi.org/10.1016/j.amjhyper.2004.05.023.

72. Knight EL, Bohn RL, Wang PS, Glynn RJ, Mogun H, Avorn J. Predictors of uncontrolled hypertension in ambulatory patients. Hypertension 2001 Oct;38(4):809–14. http://dx.doi.org/10.1161/hy0901.091681.

73. Prugger C, Keil U, Wellmann J, de Bacquer D, de Backer G, Ambrosio GB et al.; EUROASPIRE III Study Group. Blood pressure control and knowledge of target blood pressure in coronary patients across Europe: results from the EUROASPIRE III survey. J Hypertens 2011 Aug;29(8):1641–8. http://dx.doi.org/10.1097/HJH.0b013e328348efa7.

74. Lloyd-Sherlock P, Beard J, Minicuci N, Ebrahim S, Chatterji S. Hypertension among older adults in low- and middle-income countries: prevalence, awareness and control. Int J Epidemiol 2014 Feb;43(1):116–28. http://dx.doi.org/10.1093/ije/dyt215.

75. Chor D, Pinho Ribeiro AL, Sá Carvalho M, Duncan BB, Andrade Lotufo P, Araújo Nobre A et al. Prevalence, awareness, treatment and influence of socioeconomic variables on control of high blood pressure: results of the ELSA-Brasil Study. PLoS One 2015 Jun;10(6):e0127382. http://dx.doi.org/10.1371/journal.pone.0127382.

76. Shrier I, Platt RW. Reducing bias through directed acyclic graphs. BMC Med Res Methodol 2008 Oct;8:70. PubMed http://dx.doi.org/10.1186/1471-2288-8-70.

77. Thomas C, Power C. Do early life exposures explain associations in mid-adulthood between workplace factors and risk factors for cardiovascular disease? Int J Epidemiol 2010 Jun;39(3):812–24. http://dx.doi.org/10.1093/ije/dyp365.

78. Szklo M, Nieto FJ. Epidemiology. Jones & Bartlett Publishers; 2014.

Received for publication: 22 November 2017