Original Article

Job strain (demands and control model) as a predictor of cardiovascular risk factors among petrochemical personnel

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ABSTRACT

Background: One of the practical models for the assessment of stressful working conditions due to job strain is job demand and control model, which explains how physical and psychological adverse consequences, including cardiovascular risk factors can be established due to high work demands (the amount of workload, in addition to time limitations to complete that work) and low control of the worker on his/her work (lack of decision making) in the workplace. The aim of this study was to investigate how certain cardiovascular risk factors (including body mass index [BMI], heart rate, blood pressure, cholesterol and smoking) and the job demand and job control are related to each other. **Materials and Methods:** This prospective cohort study was conducted on 500 workers of the petrochemical industry in south of Iran, 2009. The study population was selected using simple random statistical method. They completed job demand and control questionnaire. The cardiovascular risk factors data was extracted from the workers hygiene profiles. Chi-square (χ^2) test and hypothesis test (η) were used to assess the possible relationship between different quantified variables, individual demographic and cardiovascular risk factors. **Results:** The results of this study revealed that a significant relationship can be found between job demand control model and cardiovascular risk factors. Chi-square test result for the heart rate showed the highest ($\chi^2 = 145.078$) relationship, the corresponding results for smoking and BMI were $\chi^2 = 85.652$ and $\chi^2 = 30.941$, respectively. Subsequently, hypothesis testing results for cholesterol and hypertension was 0.469 and 0.684, respectively. **Discussion:** Job strain is likely to be associated with an increased risk of cardiovascular risk factors among male staff in a petrochemical company in Iran. The parameters illustrated in the Job demands and control model can act as acceptable predictors for the probability of job stress occurrence followed by showing a high trend of CVD risk factors.

Key words: Cardiovascular disease risk factors, job control, job demand, job strain

INTRODUCTION

During the past 25 years, job demand control model has been widely tested known as one of the patterns for explanation of the stressful job conditions.[1]

Much of the prior research uses demand and control as dichotomous variables in models[2] [Table 1].

Job demands depend on individual workload needed to carry out that certain work as well as demands and the time limitations related to it. Job control is related to work process control, which means the ability of decision making and having the time to implement control measures over the work to accomplish it.

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Table 1: Job strain model by Karasek, 1979[42]

Job strain model	Psychological demands	
Decision latitude (control)	Low	High
High	Low strain	Active
Low	Passive	High strain

From Karasek, 1979

According to this control plan, job demand is based on the assumption that illustrates when job demands are high, job control can be much effective as a protective barrier against physical and psychological stresses as well as a factor that can create the sense of competence, effectiveness and successfulness. Recently, two other factors have been added, degree of social support and job security.[3]

Studies of health results associated with psychosocial exposures have mainly applied the Job Demand-Control model with its attitude toward job strain as a high risk exposure when evaluating the effect of psychosocial factors on health. Job strain is defined as the situation where one experiences high job demands combined with low control or decision latitude at work. Although some studies have not found increased risk related to job strain, many have illustrated an excess risk due to job strain of from 20% to 150% respectively.[4] A great deal of variability exists probably due to differences in how the exposure and outcome are evaluated. Although ratings based on broad occupational titles have had less influence, the highest risks have been observed in studies using self-ratings on the demand, control and support factors.

Another combination of control and demands shows how work can be health promoting.

Jobs with both high demand and high job control are called "active." These jobs are stimulating and challenging and are sometimes linked to positive health and well-being.[5] In a study conducted in Norway, the relationship between job demands, job resources and burnout was examined among 223 Norwegian police officers. The overall level of burnout was low among police officers compared with other occupational groups tested in Norway. Both job demands and job resources were related to job stress.[6]

Moreover, studies have indicated that high levels of job strain can affect the incidence of psychological pressures[7-9] as well as cardiovascular diseases (CVD).[10,11] On the other hand, there are some studies that illustrated some opposite results with regard to the severity of this effect on different people with a wide variety of different characteristics.[12-15] However, previous studies did not report consistent results regarding which aspects of the job strain model, including demands, control and interaction between high demand and low control, (or job strain), have the greatest consequences on the workers' health condition and was initially used to indicate patterns of depression, exhaustion and job dissatisfaction[16] however was later found as a good way to include CVD[17,18] bad health functioning[19] and also absenteeism related to sickness.[20]

In contrast according to some previous researches, CVDs are expressed as the most common cause of mortality in the United States (35.2% of all deaths in 2005). In spite of the recognition of risk factors, unexplained variability in CVD occurrence remains.[21] CVD risk factors have been found to be related to job strain, which is defined as high levels of psychological demand combined with low levels of control at work.[22] Although the link between job strain and some psychosocial factors has been described in some of the previous studies, the relative importance of different determinants of psychosocial factors, such as job control, job demand and job strain on cardiovascular risk factors has been less investigated.[11,12] In addition, the effect of such factors on cardiovascular risk factors is still not well-identified, especially in some demanding occupations such as those in the petrochemical industry.

Petrochemical industries in Iran are mostly placed in the southern parts of the country, where they are far away from city centers and have special undesirable. Remaining in such an isolated area would contribute to work strain and would be a real concern for causing a higher risk for the presence of every related disease to occupational stress including CVD or even its probable risk factors. It is noteworthy that these particular conditions have resulted in employing men more than women in this industrial area. Health cares for these at-risk people are merely limited to health examinations done by the Health and Safety Executive office yearly. These results in finding cases that may have any symptoms and treating them if necessary. However, there is no regular investigation from the viewpoint of a job strain survey and the trend in showing symptoms of cardiovascular risk factors among workers in these job positions. Applying the job content questionnaire (JCQ) to workers and between job groups in this industry would help to monitor workers strain and develop required interventions.

The aim of this study was to investigate harmful psychosocial factors such as job demands and control in the workplace and their association with the job stress and CVD risk factors amongst a sample of petrochemical personnel.

MATERIALS AND METHODS

This retrospective cohort study was carried out among employees of an Iranian petrochemical industry.

Participation in the study was voluntary and approval was received from the company ethics committee before the research started. Data was collected with the written agreement of the participants.

Target population for this retrospective cohort study was selected based on job groups. A stratified random sampling method was used to ensure a representative sample of all job groups. At the time of the study, the company had 1,200 employees. Of them, 540 subjects were chosen for to participate in this study. Finally, 500 employees completed

the questionnaires. In order to achieve more desirable results, all positions in the industry were observed by researcher regularly prior to the study.

Considering the study purposes and obtaining more precise results, the participants were randomly selected from tree main departments. In total, 500 participants included in this study consisted of operation department 85 participants, repair and maintenance department 205 participants and other jobs named in this study as service department 210 participants. The service department included some jobs such as administrative and official jobs, health care service, drivers, etc., Using the statistics formulas and calculations related to sampling method and with a confidence level of 95% and power of 80%, *r* was an approximation of correlation co-efficient between job strain and CVD risk factors such as hypertension, heartbeat, body mass index (BMI), etc., Employees with 2 years of employment and health benefit enrollment were eligible to contribute person time to study. Disease-free cohorts were formed for each outcome, consisting only of participants with no prior history of the outcome of interest. The aims of the study were evaluated from data available over 2 years, from October 2007 to December 2009.

The concepts of some psychological pressures such as job demands, job control (decision making) and their augmented effect at the time of presence both factors which means experiencing a high level of job demands and simultaneously, a low level of job control leading to job strain, were evaluated using a series of questionnaires based on Karasek's Job Demand-Control Model (1979). These questions were the same as those used in the Wale Jackson and Mularkey study (1995). Noteworthy, the validity and reliability of these questionnaires have been tested in some studies in Iran.[23-25] Chronbach's co-efficient alpha also exhibits 0.705.

The JCQ contains twenty four questions including, ten questions associated with the job control and the fourteen questions related to the concept of job demands. The scales of questionnaire compromise job demands, job decision latitude and job strain. Each item is scored on a four-point Likert scale from 1 to 4, representing either from strongly disagree to strongly agree or from often to never. According to the standard method of scoring and the JCQ instruction, provided in the JCQ and user guide, the values of scales were evaluated. Reliability and validity of the Persian version of the JCQ has been investigated in another study among hospital nurses in 2011, showing satisfactory psychometric properties of the questionnaire.[24]

Basic demographic information related to date of birth, job grade, marital status, job title and education was obtained from administrative databases.

Risk factor information including participant's physical health history was available through information provided in administrative health claims data which were all recorded in the participants' health documents. Data related to the ischemic heart disease-free participants was collected and included some CVD risk factors such as the presence of hypertension. Additional health history data was available from some plant occupational health clinics documentation, offering data on smoking, blood pressure (BP), height, weight and cholesterol levels. The data was evaluated by the occupational medicine physician of the industry. Smoking history was available from health risk behavior information previously collected and entered into a database for nearly half of employees. Data included smoking history, length, frequency and the amount of smoking or tobacco use.

A factor analysis was conducted using the most important questions for demand and control questionnaire. Demand and control variables were also coded as high, medium and low. The Chi-squared test and hypothetical test based on η value were two main statistical ways in this study.

The study protocol was approved in ethics committee of Esfahan University of Medical Sciences and all participants gave informed consent before enrollment.

At first, factor analysis method has been used in order to specify the most important job demand and control questions. Then, the Chi-squared test was applied in order to assess the possible relationship between the separated working groups in the petrochemical industry, job demand and control and some of data related to individuals demographic variables. Ultimately, hypothesis testing, based on η value, was used to assess the relationship between separated working groups and cardiovascular risk factors (Hypertension and Cholesterol). The study is a retrospective cohort study of the effects of job strain and cardiovascular outcomes.

Finally, the data obtained in each part were analyzed using SPSS-18(IBM, SPSS Inc.Chicago).[12]

RESULTS

The findings of this research consist of descriptive statistics of both qualitative and quantitative variables. Qualitative variables include, job stress (stressful working condition caused by the job demand, the job control and the interactions between them), cigarette smoking and some individual's demographic data. Quantitative variable in this study include heart disease risk factors as well as age which have been presented by concepts such as number, percent, mean, standard deviation, degree of freedom and *P* value.

The mean and standard deviation of some of the quantitative variables in the target population has been illustrated in Table 2. As it can be seen, the mean age among the study subjects is 42.52, BMI is 29.93, cholesterol is 174.18, heart rate is 79.33 and the systolic and diastolic BP are 121.02 and 81.58, respectively.

It can be inferred from the Table 3 that there is a significant relationship between age and job stress ($P = 0.00$,

$\chi^2 = 30.941$). The frequency distribution of individuals with a mean age of 30-40 year has been higher among the jobs characterized by high job stress. Among those people who reported a moderate job stress 10% were located in the ages of 40-50 and the ages of 10.4% of participants with a low job stress was also located among people with 40-50 years. A significant relationship also exists between BMI and job stress ($P = 0.01$, $\chi^2 = 38.371$). As it can be seen, among a weighted population (BMI: 25-60) the people with fairly higher job stress have a higher frequency.

There is a significant relationship between the heart rate and job stress ($\chi^2 = 145.07$, $P \leq 0.001$). As seen, the frequency of subjects with high heart rate (above 90) was highest (10.2%) among individuals with fairly high job stress, whereas the lowest frequency (1.4%) was observed among subjects with more reasonable job stress. According to Table 3, a significant relationship has been found between cigarette smoking and the job stress ($\chi^2 = 35.65$, $P < 0.001$). Moreover, among heavy smokers, the frequency distribution of persons with high job stress was interestingly higher (10.6%), Although the frequency distribution of persons among non-smokers (or smoking occasionally) is higher among subjects with more reasonable job stress (not smoking cigarette: 12.2% and smoking occasionally: 17.8%).

According to Table 4, there is a significant relationship between systolic and diastolic arterial BP and job stress. (The higher η value shows the closer relationship between BP and the severity of stress).

According to the results, a total of 103 participants reported to experience fairly high job stress of which 20.28% had a BP of 12/9 and17.7% of people with fairly high job stress had a BP of 13/10. Furthermore, among this group, people with the experience of fairly high job stress, 9.2% had a BP of 14/10 and 6.9% showed 15/10 as their BP. Of course, the percentage of people with the BP of 16/10 in this group was 6.2%.

As stated for data frequency, the number of workers with a BP of 12/9 and 13/10 was considerably higher. There is also significant relationship between the serum cholesterol value and job stress ($\eta = 0.469$). However, as given by η co-efficient, its relationship is not so strong.

Table 2: Mean (standard deviation) of quantitative variables in a sample of 500 workers at a petrochemical plant in Iran

Statistical values	Age	Cholesterol	Heart rate	BMI	SBP	DBP
Mean	42.52	174.1880	79.3380	29.9320	121.02	81.5800
SD	11.67	29.51649	9.33778	7.32685	15.23	12.30880
Minimum	22.0	111.00	60.00	19.00	100.00	40.00
Maximum	64.0	290.00	99	62.00	160.00	100.00

BMI=Body mass index, SBP=Systolic blood pressure, DBP=Diastolic blood pressure

Table 3: The prevalence of job stress and the relationship with BMI, heart rate, smoking

Variables	Job strain (high demand, low control), *n* (%)			χ^2 *P* value Mean SD
	Low	Moderate	Relatively high	
BMI				
≤25	50 (10.0)	56 (11.2)	50 (10.0)	χ^2=38.371
25-30	44 (8.8)	64 (12.8)	63 (12.6)	*P*=0.01
≥30	75 (15.0)	81 (16.2)	17 (3.4)	Mean=79.3380
Total	169 (33.8)	201 (40.2)	130 (26.0)	SD=7.32685
Heart rate				
60-70	60 (12.0)	53 (10.6)	5 (1.0)	χ^2=145.078
70-80	73 (14.6)	93 (18.6)	25 (5.0)	df=6
80-90	29 (5.8)	44 (8.8)	49 (9.8)	*P*≤0.001
≥90	7 (1.4)	11 (2.2)	51 (10.2)	Mean=79.3380
Total	169 (33.8)	201 (40.2)	130 (26.0)	SD=9.3377
Smoking consumption				
Never	61 (12.2)	57 (11.4)	32 (6.4)	χ^2=35.652
Rarely	89 (17.8)	96 (19.2)	45 (9.0)	df=4
Often	19 (3.8)	48 (9.6)	53 (10.6)	*P*=0.001
Total	169 (33.8)	201 (40.2)	130 (26.0)	Mean=0.9400
				SD=0.73313
Age				
20-30	37 (7.4)	45 (9.0)	16 (3.2)	χ^2=30.941
30-40	34 (6.8)	35 (7.0)	49 (9.8)	df=8
40-50	52 (10.4)	50 (10.0)	31 (6.2)	*P*<0.001
50-60	32 (6.4)	41 (8.2)	28 (5.6)	Mean=42.5200
≥60	14 (2.8)	30 (6.0)	6 (1.2)	SD=11.67348
Total	169 (33.8)	201 (40.2)	130 (26.0)	

BMI=Body mass index, SD=Standard deviation

Table 4: Eta coefficient and the relationship between high job demand and low job control with systolic and diastolic blood pressure

Job strain	Variable hypertension	Eta
Low	Systole	0.527
	Diastole	0.405
Moderate	Systole	0.559
	Diastole	0.442
Relatively high	Systole	0.684
	Diastole	0.692

DISCUSSION

The current study was carried out to investigate the hypothesis that how Job strain (demands and control model) can act as a predictor for cardiovascular risk factors among personnel working in one of the petrochemical plants in Iran. For this purpose, 500 petrochemical companies' staff (the total factory staff excluding those who have changed their job positions since 2007 and/or were not ready for cooperation), were considered to respond the research questionnaires. Their personal health records were also investigated. With considering the inferential analysis of data and the results achieved from this study, it was determined that job stress is significantly related with CVD risk factors.

According to the results, the mean age of the participants in this study was 42.5, which shows that the target population were approximately located in early middle age. The frequency distribution is not so different from some other studies investigated the similar subject. In a study done by Tsutsumi *et al*. on the association between job strain and prevalence of hypertension in japan the target population mean age was nearly 45.[26]

As shown in Table 3, there is a significant relationship between quantitative variable of age ($P < 0.05$) as it can be inferred from the results, the variable related to job stress with a rather high Chi-square statistic is staff age. The subjects aged 30-40 year have more job stressors than the others. It should be mentioned that most of these subjects are engaged in jobs with high job stress like working as an operation man that requires a high concentration and responsibility with a low amount of decision authority. These results were also conformed to the results achieved from some of the previous studies carried out on the subjects with approximately similar situations.[27] In a study by Collins *et al*. assigned a significant high relationship between age and job stress.[28]

The risk factors of BMI, heart rate, cigarette smoking and job stressors, i.e. low job control and high job demand. Considering BMI risk factor, the subjects are weighted due to high stress and here the Chi-square is almost high indicating that there is a strong relationship between the experience of perceived stressors at work (high job demand and low job control) and BMI. The findings of this research conform to Fox's studies in 2003 showing a significant relationship between perceived stress and its subsequent physiologic responses.[29] Moreover, in the case-control study done by Xu, *et al*. on job stress and coronary heart disease, the BMI was reported as 26.5 ± 3.1 which shows a higher trend but opposite of our study, the relationship of BMI and job stress was not statistically significant ($P = 0.08$). This disconformities can be due to the differences between target population who have different jobs in their study compared to our study in which the staff jobs are not so dispersed.[30]

A significant relationship has been found in this study between the heart rate and job stress (and it can be inferred from the results that the frequency of subjects with higher heart rate (above 90) was more among individuals with fairly high job stress, whereas the lowest frequency was observed among subjects with job stresses classified in this study as low or moderate. However, it is noteworthy that more information is needed for an accurate judgment on increased heart rate (for example regular or irregular tachycardia) due to job stress. These results were conformed to the results obtained from the researches done by Otsuka *et al*. in 2009 on the relationship between job strain and radial arterial wave reflection in middle-aged male workers in Japan who reported a high significant relationship between heart rate and job strain ($P = 0.001$).[31]

Moreover, significant relationship was found between the risk factor of cigarette smoking and high job stress so that, some workers started smoking when they entered the factory workforce, while some other, increased their cigarette consumption.

Fundamentally, cigarette smoking and the growing number of smoked cigarettes is a behavioral disorder caused by mental pressures due to workload and such behavioral disorder can be a heart disease risk factor for the smoker. With this regard, the findings of this research conform to the studies conducted by de Lange *et al*. in 2004 and Why *et al*. in 2003. The results also conform to the hypothesis that a relationship exists between job stress and the worker's low control on his/her work performance as well as the interference of this factor on the worker's behavioral characteristics which leads to the demonstration of heart disease risk factors.[32,33]

Among the quantitative variables, the value of the Chi-square statistic for heart rate is higher than all, however, since we do not know whether the increase in workers heart rate had direct reasons or indirect reasons, then we cannot judge on the issue of tachycardia while we do not know that whether stressful working conditions in petrochemical staff resulted in the increased heart rate or not. However, one of the main causes for increasing the heart rate is the workers stress and as preceded by other risk factors, it is the first factor appeared as a result of high job demand and low job control. In a study done by Stepto and Kivimäki in 2012 also an increasing trend between hear rate of participants and feeling of stress especially at the first steps of being imposed by occupational strain.[34]

It can be noteworthy that most of the times heart rate as a risk factor for CVD is followed by next risk factor which is arterial BP. As depicts in Table 4, there is a significant relationship between systolic and diastolic BP and high job stress in a systematic review done by Gilbert-Ouimet *et al*. in 2013 on adverse effects of psychosocial work factors on BP, of the 74 studies on the adverse effects of psychosocial work factors on BP, 64 used job demand-control model and showed similar results to our study.[35]

The highest frequency distribution of the population indicates that the increase in arterial BP was seen in a group with high job stress and in other words, those having been exposed to high job demands and low decision latitude. As shown in Table 4, the more the subject experiences stressful working conditions, the more he will be exposed to BP. Thus, η value is fairly high in strain group, (systolic BP: $\eta = 0.686$) (diastolic BP: $\eta = 0.696$). As the value of η increases, the relationship between the systolic and diastolic pressure and job strain would be stronger. These findings are not partly conformed to the study carried out by Greiner *et al*. on urban transit operators in which although a relationship was found between two occupational stressor dimensions, work barriers and time pressures, derived from the observer-based interview and hypertension, the statistical analysis showed an increase but not significant odds ratios. When controlling for age and years of driving in the adjusted model, the odds ratios increased and both work barriers and time pressure

significantly predicted high BP.[36] These differences can be mainly due to the fact that two parameters of age and working years have had possibly a contaminating role in our study.

There is also significant relationship between serum cholesterol value and stress (η =0.469) which did not have very strong relationship with stress in the current study. The above results achieved in this research are conformed to the study made by Stepto *et al*. In 2000 concerning the relationship between job stress with the increased concentration of free cholesterol in the early morning and the increase in probable occurrence of the subsequent heart attack.[37] In a meta-analysis of work-related stress and CVD risk factors carried out by Nyberg *et al*. in an article in 2013, job strain was linked to adverse life-style and diabetes but no association was observed between job strain and clinic blood lipids.[38,39]

This study illustrates that it is possible to apply psychosocial ratings of demand and control that are objective, assigned by occupational health professionals familiar with individual jobs, to evaluate heart disease risk factors using readily available health claims data and to use an acceptable design along with a cohort of petrochemical workers. Current research also builds upon previous work that has tried to determine the risk related with workplace psychological demands and control on health.

However, there are certain restrictions for using the job strain model. High demands and low control are the only measures of pressure at work existed, thus other potential sources of stress, such as low income, or job dissatisfaction, are ignored. In addition, Siegrist *et al*. asserted that stress at work depends not on the particular job task features alone, but also on personal attributes that influence the ability to cope.[40] Moreover, Job strain does not influence risk of CVD in the majority of the researches[5,21,41] probably because of methodological varieties in the design of the studies and the measures of job strain applied.

With considering the findings of this research, it is suggested to put more focus on psychological variables in organizations. Job redesign should be taken into consideration to increase individual control on work processes to thereby increase the individuals' social welfare as well as organization productivity. Education programs should be held in order to contribute the groups exposed to rather high job pressure (high job demand, low job control) to increase their social support; the individuals personal and physical characteristics should be taken into account upon their employment in order to increase staff motivation as well as their physical and particularly, heart health and as a consequent, to decrease heart disease risk factors such as BP, BMI, beat, cholesterol, cigarette smoking and heart diseases such as heart attack and/or at least to minimize the extent of their occurrence. As this study was carried out on one gender group including just men, it is inferred that one of our study limitations is that the findings of our study cannot be generalized to the women who are more vulnerable to be distress by job psychological pressures including high job demand and shortage of decision latitude. Moreover, using JDC model to measure subjective matter of job stress, our study was limited to evaluating just of job demands and control as two important parameters but some social factors also should be considered to be able to interpret of results more precisely.

CONCLUSION

Job strain is likely to be associated with an increased risk of cardiovascular risk factors among male staff in a petrochemical company in Iran. According to the results of the current study, the parameters illustrated in the Job demands and control model can be act as acceptable predictors for the probability of job stress occurrence following by showing a high trend of CVD risk factors particularly among those people working in a situation with a higher exposure to psychological pressures such as job demands and control. Furthermore, according to this study some management policies like positioning people according to their abilities and health eligibilities can be a great help in the field of coping stressors in the workplace. As it was mentioned before, in order to achieve more reliable results, using Job Demand-Control-Support Model to investigate occupational stress and its relationship to cardiovascular risk factors is recommended to future researchers because social support also can be measured through that model.

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