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RESOURCES MANAGEMENT AND HEALTH ECONOMY

Work stress and metabolic syndrome in radiologists: first evidence

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Abstract

Purpose Scientific data have amply demonstrated that work stress increases the risk of cardiovascular disease. However, less attention has been given to the association between stress and metabolic syndrome. In this study, our aim was to investigate the relationship between work stress and metabolic syndrome in a population of radiologists.

Materials and methods Radiologists and radiotherapists taking part in scientific conferences were invited to compile a questionnaire to evaluate work stress and the main parameters for diagnosing metabolic syndrome (obesity, hypertension, elevated cholesterol level, elevated triglycerides, and hyperglycemia).

Results Most of the doctors taking part in the survey ($n = 383$, 58.6 %) were found to have at least one pathological component; 47 subjects (7.1 %) had metabolic syndrome. All the variables indicating work stress, whether derived from Karasek's demand/control model or from the effort/reward model devised by Siegrist, were significant predictors of metabolic syndrome components. Radiologists with elevated levels of stress had a significantly higher risk of being affected by metabolic syndrome than colleagues with lower stress levels, whether stress was defined as "job strain", i.e., elevated work load and reduced discretionary power (OR 4.89, 95 % CI 2.51–9.55), or as "effort reward imbalance", i.e., mismatch between effort and reward for the work performed (OR 4.66, 95 % CI 2.17–10.02).

Conclusions Should the results of this cross-sectional study be confirmed by a subsequent longitudinal survey, they would indicate the need for prompt organizational intervention to reduce occupational stress in radiologists.

Keywords Work-related stress · Radiologist · Metabolic syndrome · Hypertension · Obesity · Elevated triglycerides · Reduced HDL cholesterol · Glucose intolerance · Job strain · Effort–reward imbalance · Overcommitment · Social support

Introduction

The literature contains ample scientific evidence of the association between work stress and the risk of cardiovascular disease [1, 2]. The Whitehall II study demonstrated that socioeconomic and familial risk factors that are present prior to employment are less important than occupational stress in the onset of cardiovascular disease [3]. Metabolic factors, such as high blood pressure, diabetes, dyslipidemia, and obesity are some important ways in which stress manifests itself. For this reason, researchers have recently recognized the need to clarify the relationship between stress and metabolic syndrome. In fact, it is thought that the latter together with life styles accounts for approximately one-third of the effect of stress on the risk of cardiovascular disease [4].

Radiologists can be exposed to considerable environmental pressure [5, 6] that may lead to a prolonged state of occupational stress [7] and a reduction in job satisfaction [8]. Comparison with other healthcare workers has shown that occupational stress is particularly high among

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radiologists [9]. Consequently we need to consider whether occupational stress in radiologists may be related to metabolic syndrome, or to its components. Our cross-sectional study is a first attempt to address this issue.

Materials and methods

Since Italian radiologists and radiotherapists are increasingly being accused of alleged malpractice [10–18], we decided to use a questionnaire to investigate the possible health effects resulting from such accusations [19]. The same questionnaire was administered to subjects taking part in a scientific conference. A total of 654 completed responses were returned.

The questionnaire examined the perception of occupational stress through the simultaneous use of the two commonest stress models: the Karasek demand–control–support (DCS) model [20] and the effort–reward imbalance (ERI) model devised by Siegrist [21].

According to the DCS model, a work environment where there is a high level of psychological demand (frenetic pace, contradictory, and excessive demands) and a low level of job control, exposes the worker to job stress. In Karasek's original model, the combination of exposure levels for demand and control gives rise to four distinct conditions. High strain jobs characterized by elevated demand and low control, lead to a greater risk of negative mental and physical health effects as compared to the other three groups. In "active" jobs, characterized by high demand and high decisional power, enhanced autonomy enables workers to avoid becoming the victims of stress. Similarly, in the other two categories, workers with low strain and high discretionary power, or passive workers (with low demand and low control) are not exposed to occupational strain. The four groups are established by dividing the scores of the demand and control scales at the median. It is also possible to use continuous scales and create a continuous variable (job strain), as a weighted ratio of the two previous scales. This model involves a third variable—social support at work—whose function is to moderate stress and was added following studies conducted by Swedish researchers [22]. The DCS model was the first to demonstrate the association between stress and pathologies; much of the literature is based on this model [23–27].

According to the ERI model, stress originates from an imbalance between the effort required to perform work and the material or immaterial rewards obtained thereby. In this model, imbalance is calculated once more as a weighted ratio between effort and reward and is a continuous variable that can be divided at the median to obtain categories of workers who are more or less exposed to stress. This model also assumes that workers with a motivational pattern of excessive work-related commitment are at greater risk [28]. Although the Karasek model provides a perfect picture of the repetitive tasks of the first industrial revolution when work was conditioned by machinery, the Siegrist model seems better suited to interpret the occupational conditions of the second industrial revolution where work has taken on a more immaterial aspect and is more invasive. In fact, in recent years, there has been a considerable increase in the number of studies based on this model. Their findings have shown that the combination of high effort and low reward constitutes a risk factor in numerous illnesses [29–33]. However, the two models offer a complementary rather than alternative solution, so a combination of the two questionnaires can provide better information on the relationship between work and health [34, 35].

Both questionnaires are available in different versions. Despite their different composition, these provide homogeneous results [36–38]. In this study, we used the 17-item DCS questionnaire and the 23-item version of the ERI questionnaire. Validation of the Italian version of these questionnaires ensured that they maintained the same structure as the original versions and were consistent throughout [39]. In the DCS questionnaire, the 'demand' scale was made up of five questions (e.g., D1: "Do you have to work very fast in your job?") (reliability, Cronbach's alpha = 0.60); the 'control' scale was the sum of six items (e.g., C2: "Does your job require a high level of skill and competence?") (alpha = 0.56) and the 'support' scale was the sum of six items (e.g., S1: "There is a calm and pleasant atmosphere where I work") (alpha = 0.87). Items were scored using a 4-point Likert's scale in which the first two scales were graded from 1 = never, hardly ever to 4 = often, while the third scale (support) was graded from 1 = strong disagreement to 4 = strong agreement. The ERI questionnaire consisted of two scales: 'effort' (alpha = 0.87) which was based on 6 questions (e.g., E1. "I have constant time pressure due to a heavy workload") ($\alpha = 0.87$) and 'reward' ($\alpha = 0.87$), evaluated by 11 items (e.g., R2 "I receive the respect I deserve from my colleagues"). The questionnaire included a third, 'overcommitment', scale (alpha = 0.91) made up of six questions (e.g., "People who know me well say that I am too committed to my work"). The responses were scored on a 5-point scale where a value of 1 corresponded to: "Strongly disagree, does not apply"; a value of 2 to: "Agree but I am not distressed" and a value of 5 to: "Strongly agree, I am greatly distressed".

Metabolic factors were investigated using the following questions: "What is your HDL-cholesterol level?" (threshold: 40 mg/dL males, 50 mg/dL females). "What is your triglyceride level?" (threshold: 150 mg/dL). "What is your blood pressure?” (threshold: 130/85 mmHg). “What is your fasting glycemia level?” (threshold: 100 mg/dL). “What is your waist circumference?” (threshold: 102 cm males, <88 females). Respondents could answer: “normal”, “abnormal” or “I’m having treatment”.

The following questions were used to investigate life styles: “How often have you smoked in the past week?” (Responses: never, I don’t smoke; never, I have stopped smoking; occasionally; every day); “Have you done any physical exercise in the past week (e.g., gym, cycling, football, swimming, running, etc.)?” (Responses: At least three times, twice, once, never); “Have you tried to cut down on salt, sugar or fats in your meals in the past week?” (Responses: always, in all meals, in most meals, occasionally, never); “How many glasses of alcoholic beverage have you drunk in the past week?” (N.B. a medium-sized glass of wine, a 33 cL bottle of beer, or a measure of spirits) Responses: none, I don’t drink alcohol; between 1 and 7 (once a day); between 8 and 16 (once at each meal); more than 16 (more than twice a day); “In the past week, have you slept less than you wanted to?” Often, sometimes, never.

Results

The radiologists, who replied to the questionnaire were mainly male ($n = 456$, 69.7 %) and employed in the public health sector ($n = 607$, 92.8 %). Table 1 illustrates the characteristics of the study population.

A total of 274 subjects (41.9 %) reported abnormal HDL cholesterol levels, while 74 subjects (11.3 %) reported an increase in triglycerides. Seventy-one subjects (10.9 %) had high blood pressure and 20 (3.1 %) were affected by glucose intolerance. One hundred and fifty-seven subjects (24 %) reported abdominal obesity. Forty-six subjects (7.1 %) who manifested three or more simultaneous pathological abnormalities were diagnosed as having metabolic syndrome (Table 2).

By analyzing the variables correlated to work stress (Table 3), we were able to build up a profile of this category of workers. On average, radiologists claimed that they had a high workload (the mean score for the demand variable was close to maximum values for the scale), but a good level of control over their work. Consequently, according to Karasek’s model, many of them could be placed in the group of “active workers” and were therefore not victims of work stress. On the other hand, those who worked at an excessively fast pace and were unable to adequately control their work flow were exposed to risk. The mean score for the job strain variable was higher than one, indicating excessive psychological strain compared to the discretionary power that could be exercised. We observed a moderate dispersion of values for social support. This indicated that there are situations in which colleagues and superiors effectively help to mitigate the effects of an excessive workload and others where, on the contrary, interpersonal difficulties added to organizational

Table 1 Characteristics of the study population

	n	(%)
Population observed	654	
Males	456	69.7
Females	198	30.3
Type of employment		
Public sector	607	92.8
Private sector	47	7.2
Role		
Chief consultant radiologist/freelance radiologist	151	23.1
Associate specialist radiologist	102	15.6
Staff grade radiologist	401	61.3
Age		
<45	219	33.5
46–50	180	27.5
51–55	154	23.5
>55	101	15.4
Years of employment		
<5	106	16.2
6–10	60	9.2
11–15	109	16.7
16–20	121	18.5
21–25	68	10.4
26–30	142	21.7
>31	48	7.3

Table 2 Criteria and prevalence of metabolic syndrome and its components

Syndrome component	n	(%)
Elevated waist circumference (>102 in men, >88 in women)	157	24.0
Elevated triglycerides (>150 mg/dL)	74	11.3
Reduced HDL cholesterol (<40 mg/dL in men, <50 mg/dL in women)	274	41.9
Glucose intolerance (fasting glucose >100 mg/dL or diabetic medication use)	20	3.1
Hypertension (systolic blood pressure >130 mmHg, diastolic blood pressure >85 mmHg, or antihypertensive medication use)	71	10.9
Metabolic syndrome		
0 components	271	41.4
1 component	221	33.8
2 components	116	17.7
3 or more of 5 components (“metabolic syndrome”)	46	7.1

Table 3 Mean values and standard deviation of work-related stress scales

	Minimum	Maximum	Mean	Standard deviation
DCS model				
Demand (range 5–20)	7	20	16.14	2.163
Control (range 6–24)	10	22	17.54	2.594
Support (range 6–24)	7	24	18.01	3.882
Job strain	0.44	2.40	1.138	0.282
ERI model				
Effort (range 6–30)	6	25	15.41	4.625
Reward (range 11–55)	18	55	41.02	8.642
Overcommitment (range 6–30)	6	30	14.49	6.467
E/R imbalance	0.25	3.06	0.918	0.517

DSC demand, support, control; *ERI* effort–reward imbalance

Table 4 Unadjusted and adjusted number of metabolic syndrome components, by categories of job strain and ERI (linear regression, continuous score independent, number of components dependent)

Stress component	Metabolic syndrome components		
	Crude	Model I*	Model II*
Demand	0.264***	0.270***	0.282***
Control	−0.232***	−0.245***	−0.241***
Support	−0.150***	−0.150***	−0.140***
Job strain (D/C ratio)	0.333***	0.354***	0.363***
Effort	0.192***	0.200***	0.183***
Reward	−0.175***	−0.204***	−0.184***
Overcommitment	0.193***	0.212***	0.213***
ERI	0.234***	0.246***	0.234***

Crude = unadjusted. Model I: adjusted for gender, and age; Model II additionally adjusted for diet, smoking, drinking, physical exercise, sleep deficit)

Significance: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

problems cause isostrain (excessive work pressure and isolation).

Siegrist's model focused on a different occupational aspect. The mean psychological effort needed to perform tasks was not held to be excessively elevated (we must consider that we are dealing with highly qualified and professional physicians), but the immaterial rewards they receive from their work were not always satisfactory. Consequently, the mean ratio between effort and reward was therefore close to one. This meant that a significant number of radiologists worked in a state of effort–reward imbalance, as they obtained less than they expected from their job. The tendency towards overcommitment was quite widespread and this aggravated the situation.

Table 5 Odds ratios (ORs) and confidence intervals at 95 % (95 % CI) for having metabolic syndrome by job strain, isostrain, effort/reward imbalance, and imbalance + overcommitment

	Unadjusted	Adjusted
High job strain	4.62 (2.47–8.63)***	4.89 (2.51–9.55)***
Isostrain	3.56 (1.92–6.61)***	3.38 (1.75–6.52)***
High ERI	4.75 (2.37–9.53)***	4.66 (2.17–10.02)***
ERI + overcommitment	5.42 (2.79–10.42)***	5.77 (2.66–12.49)***

Significance: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Linear regression analysis indicated that all the occupational stress variables were significantly associated with a prevalence of metabolic syndrome components. The increase in demand, effort, overcommitment, job strain or effort/reward imbalance, and the reduction in support or reward were associated with more frequent signs of pathology. Data adjustment for age, gender, and lifestyles did not alter these associations (Table 4).

Logistic regression provided proof that radiologists with higher stress levels, measured by both models, were at greater risk of manifesting a complete metabolic syndrome. Even after correction for confounding factors (sex, age, and lifestyles), the relationship was still statistically highly significant. The odds ratio adjusted for those who were under job strain (elevated psychological demand and low discretionary power) was 4.89 (95 % CI 2.51–9.55), for those for whom work pressure was associated with isolation, the odds ratio was 3.38 (95 % CI 1.75–6.52). Radiologists with a greater effort/reward imbalance had a relative risk of 4.66 (95 % CI 2.17–10.02), while for those where overcommitment was added to that condition, the risk was 5.77 (95 % CI 2.66–12.49) (Table 5).

Discussion

Our study demonstrated that radiologists with higher stress levels run a fourfold to sixfold greater risk of being affected by metabolic syndrome than radiologists with lower levels of stress. All work stress measurements were able to predict the presence of metabolic syndrome components in a linear way. To our knowledge, this was the first study to take this category of workers into consideration to examine the association between stress and metabolic diseases.

Our study findings are in agreement with the literature. Stressful life events have been found to induce the onset of metabolic syndrome in the general population [40]. In workers who develop a post-traumatic disorder after exposure to traumatic events, there was a significant increase in metabolic syndrome [41]. Other occupational risk factors, such as loss of sleep due to shift work [42, 43] and depression, which is also often associated with stress, are linked to metabolic syndrome [44]. Case–control studies have shown that subjects with metabolic syndrome report higher stress levels [45]. Chronic work stress, measured by the demand/control model, is associated with metabolic syndrome [46]. Workers affected by burnout show a significant increase in the prevalence of metabolic syndrome components, such as hypercholesterolemia, high blood pressure, and obesity [47].

The relationship between stress and obesity is rather complex and there are conflicting findings in the literature. A study conducted in Finland with the two stress models we used in this study showed that the lowest control and demand values and the highest levels of job strain and effort/reward imbalance are associated with an increase in body mass index (BMI) in males [48]. In contrast, an Australian study failed to find any association between levels of job strain and effort/reward imbalance and BMI [49]. These discrepancies can be explained by the fact that researchers used a cross-sectional study design or, in longitudinal studies, failed to take into consideration the physical condition of the workers at the beginning of the experiment. Findings from the Whitehall II study indicated that thin subjects who were exposed to high job strain and low control tend to get thinner, while those who are initially overweight tend to put on more weight when they are under stress [50]. A recent analysis summarizing the findings of 13 studies conducted in Europe, confirmed that there is a U-shaped association between stress and body weight, whereby thin subjects lose weight, while obese individuals get fatter [51].

Clearly the relationship between stress and metabolic syndrome is so complex that it would be difficult for a single cross-sectional study to draw any definite conclusions. Our findings must be treated with considerable caution for a number of reasons. First of all, no cross-sectional study is able to infer the direction of phenomena that have been seen to be related. Our single study is not sufficient to exclude the possibility of inverse causality, i.e., that it is the onset of metabolic syndrome or its components that are responsible for an increase in work stress, even though knowledge of the literature would seem to exclude such a hypothesis.

The second important limiting factor in our study regards the voluntary participation of the radiologists. Because the cases were not randomized, the prevalence of the disorders reported cannot be extended to all Italian radiologists. In our study, prevalence values for metabolic syndrome are lower than those estimated for the US population. The third National Health and Nutrition Examination Survey (NHANES III) recorded a prevalence of metabolic syndrome in the total population of 21.8 % [52]. In NHANES III, the prevalence of abdominal obesity was approximately 50 % in females and 30 % in males, respectively. This was also higher than the value found in our study as were the US population levels of impaired HDL cholesterol, hyperglycemia, and hypertension. The few data available for Italy confirm that metabolic syndrome and its components occur more frequently than was observed in our sample. The Italian Longitudinal Study on Aging (ILSA) reported a metabolic syndrome prevalence of 25.9 % [53]. A study conducted in the Marche Region of Italy found a metabolic syndrome prevalence of 11.5 % in the 36–42 age group and of 22.5 % in subjects between the age of 43 and 60 years [54]. The prevalence of metabolic syndrome and its components in our sample was therefore less than that in the general Italian population and other industrialized countries. This demonstrated that in our sample group at least, the health level of Italian doctors was higher than that of the general population—a fact that had already been ascertained in previous epidemiological studies [55]. It also indicated that the subjects taking part in our study were not prompted to do so because they were suffering from one of the conditions under investigation. This was important since we know that being affected by any morbid condition induces individuals to be more precise when recalling all the possible causal factors for that illness. This phenomenon, known as "recall bias", can give rise to fictitious associations. The limited number of sick subjects in our survey reduced the impact of such an effect compared with what may occur in case–control studies. Another positive aspect of our study was the fact that the gender distribution in our sample (69.7 % males, 30.3 % females) was similar to that of the 2009 membership of the Italian Association of Radiologists (SIRM), in which 61.7 % of the 9,158 members were males and 38.2 % females. Thus, self-selection of participants did not distort gender results. This was important as we know gender plays an important role in metabolic diseases. Our statistics were, however, also adjusted for gender.

Since there was no collection of analytical or objective data in our study, the third limitation concerns the fact that it was not possible to verify the accuracy of the responses given. In epidemiological studies where self-assessment is made of both the risk factors and their consequences, what is known as "common method variance" may occur, i.e., individuals with "negative affectivity" tend to give a negative answer to all the questions, thus, influencing the strength of the association between risk factors and outcome. However, it has been shown that this is not an automatic process and that when it occurs it has little effect [56] and tends to diminish the strength of the association rather than boost it [57]. In our case, the fact that the individuals questioned were all doctors makes us confident with regard to the accuracy of the clinical parameters reported.

Our study demonstrated that radiologists are an occupational category that is exposed to considerable number of critical situations and that they often suffer from stress even though they carry out their work in a highly protected and controlled environment. The prevalence of blood pressure, obesity, dyslipidemia, and diabetes was higher in subjects with a more elevated level of job strain. This finding should encourage researchers to carry out more prospective studies. Moreover, in our opinion, the same precaution that is used for safety in the radiological field should be extended to include psychosocial issues. Programmes designed to reduce work stress could provide significant advantages for radiologists in terms of the health and productivity.

Conflict of interest Nicola Magnavita, Adriano Fileni declare no conflict of interest.

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