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ORIGINAL PAPER

Dynamics of stress as a predictor of health consequences in Polish drilling platform workers. Longitudinal study: part I

Irena Leszczyńska, Maria Jeżewska, Marta Grubman-Nowak

Institute of Maritime and Tropical Medicine, Medical University of Gdansk, Poland

ABSTRACT

Background and aim: *The subject of presented article is the evaluation of the relationship between the way of adaptation to work-related stress and chosen health indicators among drilling platform workers in Poland. The study procedure is a longitudinal research, including data analysis from 1993 to 2013.*

Materials and methods: *167 Polish platform male workers with an average age of 42 years have been examined. The studies include, according to the triangulation method, data from 3 sources: data concerning the so-called 'objective' and 'subjective' stress, personality and temperamental examinations and data concerning health state.*

Results: *Stress affects health negatively, the higher subjective and objective stress, the worse health indicators: higher body mass index, more declared health ailments and worse evaluation of personal health (r = –0.23). Stress also affects health via 2 indirect tracts: through the kind of stress adaptation (stress dynamics) (r = –0.43) and through coping — depositional stress coping style (r = 0.41).*

Conclusions: *Stress adaptation (stress dynamics) and coping style included in the study in longer perspective show that those drilling platform workers, who declare the decrease of stress over the years, present worse health indicators than those, who declare variability in the ways of adaptation to stress.*

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Key words: work-related stress, drilling platforms, well-being, health consequences

INTRODUCTION

Work on drilling platforms is considered as a stressful occupation, and work-related stress is a risk factor of many diseases. Stress at work is a negative experience induced by stressors at the work place [1–3]. It is a complex, multidimensional and dynamic process, during which the perceived stress factors can directly or indirectly cause psychosomatic and physiological problems [4–6]. These effects can be moderated by individual factors — temperament and personality, as well as psychosocial factors, such as perceived job demands, control, social support, perceived work environment [5, 6].

In consideration of work in the marine environment, including drilling platforms, a particularly important role is being played by the concept of mental stress and participation and role of psychosocial factors as its source [7–9]. Exposure to harmful physical and psychosocial factors occurs simultaneously. In this approach we are dealing with at least 2 processes — the direct mechanism of somatic disorders and psychological effects of stress.

Stressors occurring on marine drilling platforms (subjective, objective and health indicators) have negative consequences for the individual categories of health and well-being at work. This may be the result of different types of somatic disorders, mental dysfunctions, and sometimes — in extreme cases — the necessity of resignation from work. In adaptation to extremely difficult conditions, undoubtedly, the most significant role is being played by the individual characteristics that modify health consequences of stress positively or negatively.

Dr Maria Jeżewska, Clinic of Occupational and Internal Diseases, Institute of Maritime and Tropical Medicine, Medical University of Gdansk, ul. Powstania Styczniowego 9B, 81–519 Gdynia, Poland, tel: +48 58 349 19 32, e-mail: mariajez@gumed.edu.pl

Health consequences play an important role in the meaning of work-related stress and its effects. Rich literature on health consequences that result from stress on drilling platforms shows, that this is an important issue, however, the group of people working at sea is perceived as healthier than other types of occupations [10, 11]. Stress at work can cause musculoskeletal pain [10], cardiovascular disorders [12], gastrointestinal disorders and mental problems [10, 13]. Musculoskeletal pains are the most common ailments and include the majority of workers in modern society. The most significant psychosocial factors affecting musculoskeletal system are: work demands, freedom of decision-making, symptoms of stress, social support, type A behaviour and psychological anxiety. Bonger et al. [14] showed that repetitive work, high work overload, time pressure, low control, lack of social support and stress symptoms may be associated with musculoskeletal problems. The authors of research on drilling platforms beyond the specific categories of symptoms often include a general division of physical and psychological ailments [10, 13, 14]. Bjerkan's studies [10] on the relationship between health, safety and working environment show, that there are important indicators of health: musculoskeletal pain (neck, shoulder, back, knee, hip), allergic reactions, and hearing disorders. Norman et al. [15] showed that musculoskeletal pain disorders are the main reason for medical evacuation amongst the employees of the industry. They are also the most common cause of loss of work licence in the Norwegian petroleum industry [16]. This allows to conclude, that this musculoskeletal pain is the important problem at work on offshore installations. Comparing the research of different authors about drilling platforms workers a conclusion can be drawn, that the most common ailments in the industry are those from the following categories such as: musculoskeletal disorders, cardiovascular diseases, respiratory problems, hearing disorders, endocrine disorders (diabetes) and nervous system disorders [10, 13, 16].

Health consequences of stress and coping with it are diverse — they include subjective and objective aspects. Indicators of health consequences, as the likely results of occupational stress, can be divided into at least 5 groups, depending on the level of objectivity:

1. 'Objective' level indicators, such as the number and type of symptoms — i.e. body mass index (BMI) and an assessment of one's own health.
2. Declaration level — 'subjective' indicators — i.e. an assessment of mental and physical well-being, general perception of health.
3. Behavioural level — i.e. behaviours that may be associated with stress (not necessarily conscious): smoking, eating habits (different during work on a platform than at home), work absence.
4. The 4th level — probably associated with mental well-being — the aspect of manifested mood, generally perceived stress at work and at home.
5. Physiological consequences of stress and also ones based on behavioural indicators, such as problems with falling asleep and waking up, etc.

This report relates to stress factors of the 1st level — the objective indicators combined with the assessment of the own health state.

RESEARCH PROBLEM

To establish whether the way of adaptation to work-related stress during the period of 20 years (stress dynamics) is connected with health condition of platform workers.

MATERIALS AND METHODS

167 drilling platform male workers with average age of 42 years and average length of service of 12 years have been examined. The study was conducted in the work environment — on drilling rigs during repeated multi-day stays over the period of 20 years, since 1993 to 2013. The same employees were being tested during 20 years in essentially unchanged operating conditions for the same 2 platforms. Each employee has been examined at least twice, mostly 5–6 times. Demographic characteristics of the examined group is presented in Table 1.

The following methods have been applied:

— For the perceived work-related stress: the Questionnaire for Subjective Evaluation of Work [17]. The questionnaire concerns subjective opinions of the workers on: sense of mental workload, lack of rewards at work, sense of insecurity caused by the organisation of work, social contacts, sense of threat, physical disturbance, unpleasant working conditions, lack of control, lack of support and accountability.
— For the evaluation of psychosocial conditions: Psychosocial Working Conditions Questionnaire. The questionnaire investigates individual impressions of employees about the types of work burden using 3 scales: work demands, control at work, social support at the work place and additional scales connected with evaluation of physical and psychological well-being and the need for change [18].
— To diagnose the styles of coping with stress: Coping Inventory for Stressful Situations [19].
— Data from a survey on health indicators of employees according to their own opinion, including: questions about height and weight, number and types of ailments and the opinions about the impact of work on various aspects of life — the level of stress at work, at home, effectiveness of coping with difficult situations, commitment to the company and others.

Table 1. Demographic characteristics of the examined group

Demographic variable	Category of demographic characteristics	Number (%)
Age	Under 30 years	27 (14.6%)
	31–40 years	61 (33.0%)
	41–50 years	49 (26.5%)
	51–60 years	40 (21.6%)
	Over 60 years	8 (4.3%)
Length of service	Under 5 years	45 (24.5%)
	6 to 10 years	28 (15.2%)
	11 to 15 years	57 (31.0%)
	16–25 years	31 (16.8%)
	25 years and more	23 (12.5%)
Education	Vocational	31 (16.85%)
	Secondary level	78 (42.39%)
	Higher	75 (40.76%)
Marital status	Married	143 (77.72%)
	Divorced/married in second marriage	8 (4.35%)
	Divorced	4 (2.17%)
	Widower	1 (0.54%)
	Single	2 (1.09%)
	Concubinage	3 (1.63%)
	Bachelor	23 (12.50%)
Platform	Exploiting	74 (40.44%)
	Drilling	109 (59.56%)
Work position	Managerial	59 (32.07%)
	Non-managerial	125 (67.93%)
Service	Drilling	50 (27.32%)
	Energy-mechanical	46 (25.14%)
	Hotel	22 (12.02%)
	Marine	35 (19.13%)
	Exploiting	30 (16.39%)

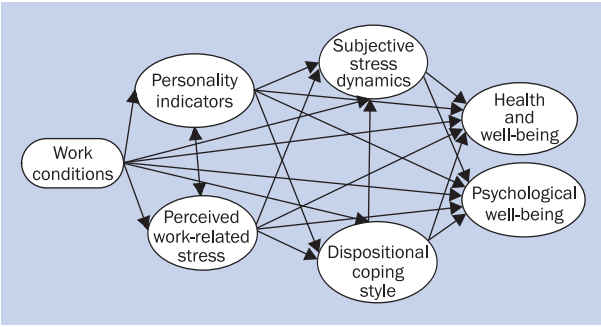

Figure 1. Theoretical model

RESULTS

A model was prepared with the aim to explain the consequences of health and quality of life by means of the impact of mechanisms of action of working conditions directly as well as indirectly through stress dynamics and style of coping with it. The dynamics of stress and coping styles are the mediators of these relationships. The term stress dynamics can be understood as the way the platform workers have been adapting to it over the 20 years of follow-ups. The theoretical model has been created (cluster analysis), on the basis of which 3 groups of workers have been determined: the 1st group, so-called „Immunized", consisted of workers in which stress has been systematically decreasing over 20 years; in the 2nd group, called „Sensitizing", were those, in which stress has been systematically increasing; the 3rd group, called „Changing", were those, in which stress first quickly decreased and then increased. Coping style is a depositional style of overcoming stressful situation, specific to each employee, containing different proportions of style focused on the task, emotions or avoidance.

Working conditions are the most objective: length of service, position (managerial or non-managerial), shift work and the conditions resulting from the assessment of psychosocial burden (demands, control and social support, based on the concept of Karasek [6]). Determinants of personality traits and perceived stress are independent latent variables, ways to adapt to stress during 20 years (at the rate of stress), dispositional coping styles are the mediators of stress and perceived physical and mental well-being is dependent on endogenous variables — health consequences of work-related stress.

STRESS DYNAMICS

In order to determine the types of stress dynamics, a cluster analysis has been conducted using Ward's method based on a matrix of Euclidean distances between the studied individuals, calculated for their similarities to the dimensions, specified by the parameters of a quadratic function, i.e., "a", "b" and "c". As a result, it will be possible to classify the types of dynamics of stress.

Dendrogram above (Fig. 1) indicates, that in the population there are probably 3 groups of people (men) with different dynamics of stress. These 3 groups allow to explain 51% of the variance results between the individuals, which is a very satisfactory result.

To make the description of the preferred cluster, one-way ANOVA analysis must be performed (Table 2), where the independent variable is the type of dynamics (highlighted cluster), while the dependent variables are the parameters of a quadratic function — "a", "b" and "c". This analysis will help to determine which types of dynamics differ from each other in terms of the various parameters defining the dynamics.

Table 2. Results of one-way ANOVA (Between-Subjects One-Way Analysis of variance)

Parameter	Cluster 1 (n = 49)		Cluster 2 (n = 66)		Cluster 3 (n = 52)		Significance test		Tukey's post-hoc test		
	M	SD	M	SD	M	SD	F(2;164)	η	1 vs. 2	1 vs. 3	2 vs. 3
a	6.28	0.55	1.03	0.58	5.69	0.62	360.293	0.829	< 0.01	< 0.05	< 0.01
b	–0.51	0.12	0.89	0.09	0.09	0.14	293.221	0.963	< 0.01	< 0.01	< 0.01
c	0.06	0.11	–0.03	0.17	1.07	0.12	295.876	0.802	< 0.05	< 0.01	< 0.05

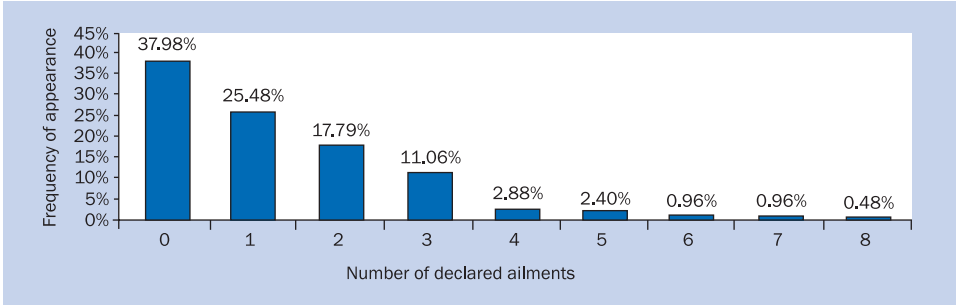

Figure 2. Number and frequency of declared ailments

The results of the analysis and comparisons have shown that, indeed, 3 groups differ significantly, what is presented by the high value of F-statistic, which is always highly significant ($p < 0.001$), with a very high rate of χ^2. In this case one can say that in fact the relationship between the model parameters and the type of dynamics is very strong in relation to all the parameters of a quadratic function. Furthermore, post-hoc comparisons indicate that each group significantly differs from another $p < 0.05$.

First cluster is characterised by a relatively high starting point when compared with other groups — the 3rd sten (M = 6.28, SD = 0.55), but they also have a tendency to decrease in the level of stress over time (M = –0.51, SD = 0.12), while the decrease is almost constant (M = 0.06, SD = 0.11). In other words, stress amongst workers in this group systematically decreases. The group has been called "Immunized to stress" (IS).

The second type of cluster refers to people with very low levels of stress at the beginning (M = 1.03, SD = 0.58), but stress at this group is steadily increasing (M = 0.89, SD = 0.09), while these changes are rather linear, i.e. systematic (M = –0.03, SD = 0.17). This group is called "Sensitizing to stress" (SS).

People with the 3rd type of cluster are characterised by moderately high (for this population) starting level of stress (M = 5.69, SD = 0.62), with a slight upward trend — practically low level of changes — (M = 0.09, SD = 0.14). In this group the strongest tendency to stress swings can be observed (M = 1.07, SD = 0.12). This means that they have a dynamic "U" — stress is initially quite high, then it decreases and increases again. This group is called "Changing in experience of stress" (CS).

STRESS DYNAMICS VS. HEALTH

General analysis of drilling platforms workers' health has shown that majority of them (62.02%, n = 104) in the last period of employment reports the occurrence of at least 1 of the health ailments (Fig. 2).

Due to the fact that some employees have more than 1 health problem — sometimes even in the same category (i.e. hypertension and myocardial infarction) — the number of illnesses may be greater or equal to the number of people suffering.

The surveyed workers reported an average of M = 1.38 complaints with the SD = 1.59. Half of the respondents reported at most 0.98 ailments. The results are presented in Table 3.

Table 3. Ailments and frequency of appearance

	Number of ailments (% ailments)	Number of people (% people)
Musculoskeletal disorders	33 (23.91%)	31 (24.22%)
Respiratory diseases	30 (21.74%)	29 (22.66%)
Cardiovascular diseases	24 (17.39%)	24 (18.75%)
Neurological and sensory organs	23 (16.67%)	17 (13.28%)
Injuries related to the accident	15 (10.87%)	14 (10.94%)
Diseases of the digestive system	9 (6.52%)	9 (7.03%)
Skin diseases	3 (2.17%)	3 (2.34%)
Endocrine and metabolic disorders	1 (0.72%)	1 (0.78%)

To answer to the question whether the dynamics of stress is associated with health, we have analysed the dynamics of stress vs. reporting health problems in the last period of employment cross-sectionally.

The results (Table 4) indicate, that there is a statistically significant and strong correlation ($\chi^2(2) = 40.236$; $p < 0.001$; $V = 0.49$) between the type of stress dynamics and reporting health problems. The group that reported symptoms most frequently is cluster 2 (Sensitizing to stress), while the group clearly less notifying about health problems are people from cluster 3 (Changing stress dynamics). The risk of health problems in cluster 3 is 9 times lower than the health risk in cluster 2 (OR = 9.23) and more than 10 times smaller than it happens in cluster 1 (OR = 10.59).

Next we have considered whether the average number of symptoms reported by workers with different dynamics of stress varies. In order to answer to such question, a Kruskall-Wallis test for independent samples has been performed (Table 5). This test verifies the hypothesis, that the average rank of the number of reported problems is the same in all groups compared with different stress dynamics. It is a non-parametric equivalent of one-way ANOVA, which would verify the hypothesis, that the average number of problems is the same in all compared groups.

The results of the analysis indicate that there are statistically significant, although very weak, differences in the number of reported symptoms ($\chi^2(2) = 6.884$; $p = 0.032$; $\varepsilon = 0.05$). People from cluster 3, while reporting health problems least frequently, declare the highest number of ailments. In other words, they declare either none or many.

In the same way you can carry out an analysis about the opinion of platform workers on their medical condition (Fig. 3).

Researched workers rated their health at M = 7.90 with a SD = 1.40, with half of them evaluating it at most $Q_2 = 7.81$. Simultaneously there is a moderately strong positive correlation between the number of reported complaints and opinion about their own health (rs = –0.35).

The results of the analysis indicate that the opinions about own health do not differ significantly between 3 dynamics of stress (Table 6).

Table 4. Frequency of declared ailments by the workers with different stress dynamics

	Cluster 1	Cluster 2	Cluster 3	Overall
Yes	39 (37.50%)	51 (49.04%)	14 (13.46%)	104 (100%)
No	10 (15.87%)	15 (23.81%)	38 (60.32%)	63 (100%)
Overall	49 (29.34%)	66 (39.52%)	52 (31.14%)	167 (100%)

$\chi^2(2) = 40.236$; $p < 0.001$; $V = 0.49$

Table 5. Summation of the number of declared ailments based on stress dynamics

Cluster 1				Cluster 2				Cluster 3				Kruskall-Wallis test		
M	SD	Q_2	R	M	SD	Q_2	R	M	SD	Q_2	R	$\chi^2(2)$	p	ε
1.32	1.58	0.93	68.52	1.91	1.62	0.94	78.3	1.89	2.03	1.11	88.4	6.884	0.032	0.05

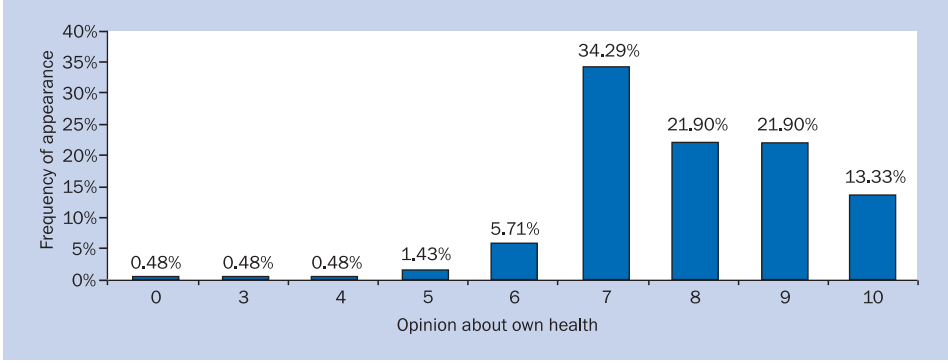

Figure 3. Opinion about own health among drilling platform workers

Table 6. Comparison of opinion about one's health depending on stress dynamics

Cluster 1				Cluster 2				Cluster 3				Kruskall-Wallis test		
M	SD	Q_2	R	M	SD	Q_2	R	M	SD	Q_2	R	$\chi^2(2)$	p	ε
7.79	1.41	8.01	81.3	7.84	1.99	7.78	81.4	8.03	1.78	7.82	83.1	2.395	0.302	7.79

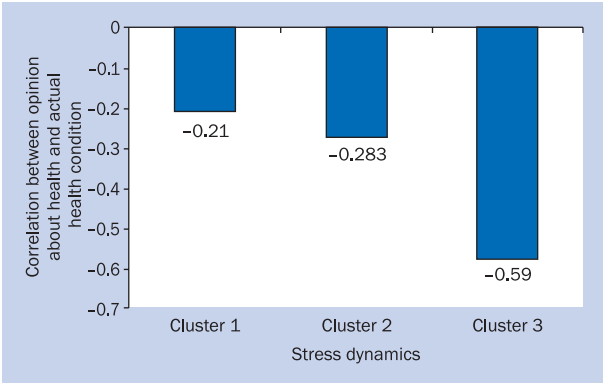

Figure 4. Stress dynamics and the relationship between the opinion about own health and the actual state

Table 7. Body mass index (BMI) level of the workers

BMI	No.	Per cent
Normal	51	30.54%
Light overweight	84	50.30%
Overweight	27	16.17%
Obesity	5	2.99%
Overall	167	100%

Table 8. Body mass index (BMI) and type of dynamics

BMI	Cluster 1	Cluster 2	Cluster 3
Normal	26 (42.01%)	28 (51.76%)	2 (2.31%)
Overweight	11 (13.10%)	32 (38.10%)	41 (48.81%)
Light overweight	12 (44.44%)	6 (22.22%)	9 (33.33%)
Obesity	4 (80.00%)	1 (20.00%)	0 (0%)
Overall	49 (28.82%)	66 (38.82%)	52 (30.59%)

We have analysed whether the number of complaints and subjective measure of health — i.e. own opinion about health — go hand in hand with similar potency in groups. To answer to this question we have carried out a comparative analysis of the strength of correlation between 2 measures in 3 groups using the χ^2-Kullback test. This test allows to verify the hypothesis that the correlation between 2 variables in the compared groups is the same.

The results of the analysis indicate that there is a significant difference connected with the strength of correlation between the opinion about own health and the actual state ($\chi^2(2) = 7.177$; $p = 0.028$). The carried out post-hoc test indicated, that men from cluster 3 present more realistic attitude towards the assessment of their own health (Fig. 4).

Another indicator of health status is BMI of employees (Table 7). The level assumed by BMI category: normal weight 20–25 kg/m^2, light overweight to 30 kg/m^2, overweight — up to 35 kg/m^2, and obesity above 35 kg/m^2 (according to Polish Dietetic Society).

The results indicate that the drilling platform workers present BMI in the range of 21 to 47 kg/m^2, with a mean (M) = 27.68 kg/m^2 with the standard deviation (SD) = 3.89 kg/m^2 and half of the subjects 27 kg/m^2.

Cross-tabs test indicates, that there is a statistically significant relationship between BMI and the type of stress dynamics $\chi^2(8) = 51.075$; $p < 0.001$; Cc = 0.48. People with decreasing stress level (cluster 1) show the highest percentage of obesity, while those with changing dynamics (cluster 3) present the average weight slightly above the norm (Table 8).

There are 2 interesting correlations: 1) between BMI and the number of reported symptoms; 2) between BMI and opinion about own health. It turns out that, regardless of the type of stress dynamics, there are statistically significant and moderately strong positive correlations between the number of reported symptoms and BMI ($r_s = 34$, $p < 0.001$).

MODEL OF HEALTH PREDICTION

In order to verify the hypotheses relating to the effects of stress on the health state prediction of platform workers, a track model was analysed (SEM analysis) and tested by maximum likelihood method (Fig. 5) [20]. In this model we have tested the relationship between aggravating psychosocial factors (demands, control and social support), the level of stress (objective and subjective), the dynamics of stress, coping and health.

The results of the analysis indicate that the estimated model is accurate and that it reflects the actual relationship between the analysed variables, while the error estimates are statistically insignificant (fit indices: RMSEA = 0.067, CFI = 0.951).

Stress affects health directly negatively, the higher subjective and objective stress, the worse health indicators: higher BMI, greater number of reported symptoms and worse assessment of own health ($r = -0.23$).

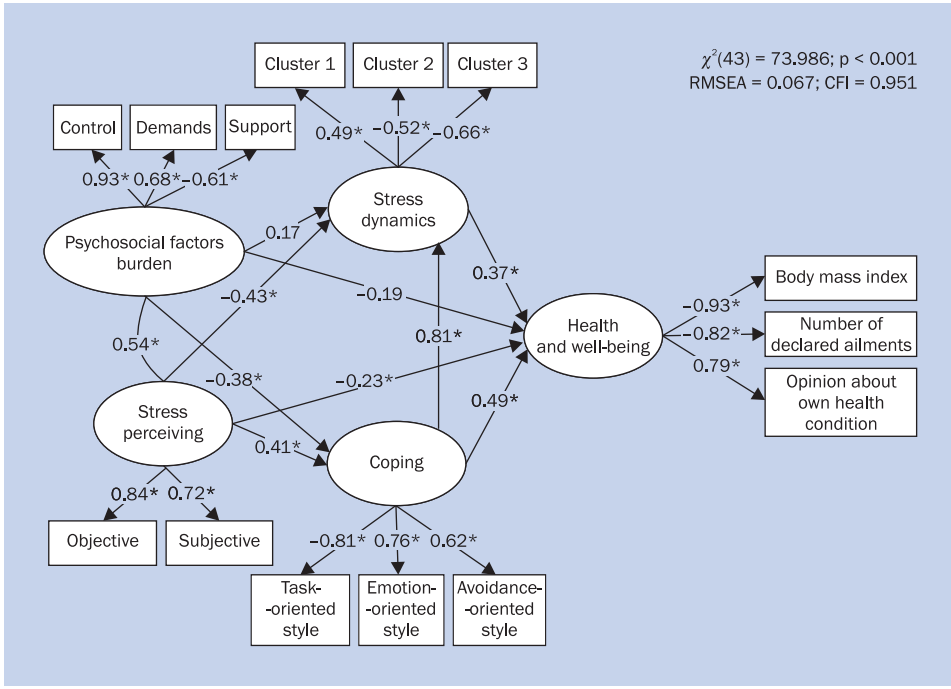

Figure 5. SEM model of health prediction; *statistical significance

Table 9. Summation of the mediating effects of the relationship between stress and psychosocial burden on health indicators moderation

		Stress and its perception			Psychosocial burden		
		Indirect	Direct	Total	Indirect	Direct	Total
Beta		–0.18	–0.21	–0.39	–0.24	–0.19	–0.43
95% significance interval	Lower limit	–0.48	–0.51	–0.68	–0.52	–0.36	–0.62
	Upper limit	–0.03	–0.09	–0.13	–0.08	0.03	–0.09
p		0.023*	0.009**	0.001**	0.021*	0.125	0.016*

*p < 0.05; **p < 0.001

Stress also interacts with health in 2 indirect ways: through the way of adapting to stress (stress dynamics) (r = –0.43) and by dispositional style of coping (r = 0.41) (Table 9).

The higher stress level, the greater probability of belonging to cluster 1 (IS) and 3 (SS), and smaller to cluster 1 (IS). In clusters 2 (SS) and 3 (CS) stress can impact on health consequences positively: higher BMI, greater number of reported symptoms and worse assessment of their own health.

In cluster 1 stress level is steadily decreasing, but health consequences are increasing. The greater experience of stress, the greater health consequences, despite the fact that over the years they developed resistance to feeling stressed.

The second indirect path of stress and health interaction goes through the dispositional coping style. In employees with cluster 2, health consequences after many years are less significant than in cluster 1. At the same time employees from clusters 2 and 3 share dispositional coping styles: the emotional and avoidance is proportionally higher in comparison with the task-oriented style. The "tree" analysis shows that people with higher share of emotional style and avoidance in relation to the style of performance, in longer perspective suffer fewer health consequences.

Adaptation to stress (stress dynamics), that is coping strategy over longer period of time, may show that higher stress does not necessarily have to be associated with greater health consequences.

Coping style also depends on the objective situation related to working conditions on drilling platforms. The more the employee engages the dispositional emotional and avoidant-oriented coping and the fewer actively applies task-oriented strategies, the less health consequences. The better perceived stress, or lower denying of feeling stressed out, the more favourable effect of stress on health.

The psychosocial factors burden (control, requirements and social support) does not impact health consequences directly (r = –0.19). These factors do not interact directly with stress, but affect it indirectly through coping (r = –0.38).

The higher perceived needs and sense of control at work, and less social support, the lower share of emotional and avoidance coping styles and higher health consequences. Employees engaging task-oriented style of coping (the highest proportion in relation to the styles of emotional and avoidance) present greater health consequences, such as: higher number of symptoms, higher levels of BMI and worse assessment of health. Dispositional style of coping is a mediator between the total psychosocial factors burden and health consequences of occupational stress.

The perception of work requiring a great sense of control and lack of social support associated with dominant task-oriented style may contribute to negative health consequences.

DISCUSSION

The results show that the level of stress in cluster 1 (Immunized to the perception of stress) during 20 years of follow up, is steadily decreasing but the number of health consequences is increasing. The higher experience of stress in this group of workers, the higher health consequences, despite the fact that over the years they developed resistance to feeling of stress. Perhaps this is a seeming immunization. One would therefore think about the falsification of declarations of stress, in addition, among those who initially presented the highest level. This may be connected with high need for social approval and presenting milder than in reality vision of stress on drilling platform, or is due to the necessity of fulfilling the role of a strong, hard man who does not admit to being stressed out.

In comparison with other studies on the health consequences of work-related stress in drilling platform workers in Norway, UK and China, in the present study we observed more complaints about hearing disorders and obesity. There are no mental and psychological ailments, presented in other studies [13, 16] but this is probably the specificity of Polish platforms, requiring further research, including comparison with other countries.

CONCLUSIONS

The article in its assumption treats stress as a dynamic, changing over time process, taking into account the prospective test procedure and triangulation, i.e. the study of stress from 3 sources: objective, subjective and health indicators.

Drilling platform workers, during the 20 years of observation, declared a decline of work-related stress (developed resistance to feeling stress), using the task-oriented style of coping more often than emotional and avoidance, as a result experience greater health consequence, such as: larger number of ailments, higher levels of BMI and worse assessment of their health status.

The higher level of stress, the greater probability of belonging to clusters 2 and 3 (where stress increases over time or is changeable), than to cluster 1 (where stress decreases). For people in cluster 3 (stress is decreasing at first and then increasing), stress can have a positive impact on health consequences. Adaptation to stress is flexible and consequently promotes health through included in this part of research indicators, i.e. the number of symptoms, the level of BMI and evaluation of own health condition.

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