Eur J Appl Physiol (1988) 57:282–290

European Journal of
Applied
Physiology
and Occupational Physiology

Psychological factors and self-reports of muscle pain

H. Ursin, I. M. Endresen, and G. Ursin

Department of Physiological Psychology and Department of Epidemiology and Preventive Medicine, University of Bergen, N Bergen, Norway

Summary. Factorial analyses of subjectively felt health complaints in a population of 400 males and 74 females revealed nine orthogonal (independent) factors. One factor (Factor 4) involved pain in the neck, pain in the back, pain in arms and shoulders, and migraine. This type of complaint did not relate to anxiety and depression. The prevalence of muscle pains varied between the sexes, and the types of occupations. Shiftwork was also important. 54% of the women and 40% of the men in the total population had some forms of muscle pain, but only 8% of the women and 3% of the men felt this to be a really serious problem. Psychological factors explained only moderate amounts of variance of muscle pain when the population was taken as a whole. However, within each type of occupation, psychological factors explained a considerable amount of the variance.

Key words: Muscle pain – Stress – Health questionnaire

Introduction

In studying the development of musculo-skeletal complaints in workers, the main focus has been the strain arising from body posture and the physical work load. However, muscle tension may also be generated by psychological factors. Jacobson (1938) defined muscle tension as a state of nervous tension or hyperexcitability with definite pathological connotations. This was the background for his postulates of anxiety relief by "progressive relaxation".

Offprint requests to: H. Ursin at the above address

The definitions of muscle tension differ. All seem to include some degree of muscle contraction. Since all behaviour and all behavioural expressions are mediated by muscles, it may be tempting to conclude that there are as many "muscle tension states" in the body as there are possible combinations of muscle contractions. A general muscle tension factor is evident when simultaneous recordings are made from many muscle groups (Balshan 1962; Westgaard and Bjørklund 1987). This general factor tends to drown in the activity derived from specific muscle actions. The general tension factor is unrelated to specific responses or postural loads. It appears in recordings during states such as anxiety, preparation for difficult tasks, emotional situations and high levels of motivation. In both humans and monkeys muscle tension, measured as electromyographic (EMG) activity, increases when a subject prepares for a task (Evarts et al. 1984). Many studies show an inverted relationship to performance, too much or too little general tension may be detrimental to performance (Malmo 1957), but only under specific circumstances (Hockey 1986). The resources invested by a subject in a particular task ("effort") is related to muscle tension, in particular in the neck muscles (Eason and White 1961). Accordingly, muscle tension may also be used as evidence of motivation (see Hockey et al. 1986, for references).

The so called EMG "gradient" may be important for the understanding of the relationships between psychological factors, effort, activation, and muscle tension. This is the progressive rise in muscle tension observed at the initiation of a task and continuing until the task is completed, and is also found in muscle groups not involved in the response (Malmo and Davies 1956; Svebak 1984). A decrease in tension is a characteristic of relaxation and concomitant with the state of sleep (Rechtschaffen and Kales 1968). Jacobson (1938) referred to the general muscle tension as anxiety. This is but one aspect of general muscle tension. Within conventional neurophysiological thinking, the general factor seems well accounted for by the general activation concept of Moruzzi and Magoun (1949). This has also been shown to be a valid concept within psychophysiology (Malmo 1957) and for psychosomatic theory (see Ursin 1982, 1986, for discussion).

Pribram and McGuinness (1975) suggested that the immediate physiological responses of the orienting response should be referred to as "arousal", the more tonic readiness to respond as "activation", and, finally, to the coordination between these two processes as "effort". In the following we will follow this nomenclature. An essential element in the theoretical position underlying this paper is the assumption of relationships between prolonged states of "tonic activation" or stress responses for the development of somatic pathology (Ursin 1980). Tonic activation is the general response seen in non-coping subjects or before coping has been established (Ursin 1978). It is this and only this type of "stress" or activation response which may produce pathology, and only if sustained (Ursin 1980).

Specific hypotheses have been developed as to how this psychological state influences blood pressure and cardiovascular pathology (Knardahl and Ursin 1985), gastric (and probably duodenal) ulceration (Murison and Isaksen 1983), and the brain transmitter systems involved in depression (Anisman and Zacharko 1982) and psychoses in general (Coover et al. 1983). No corresponding pathophysiological model may be offered for muscle pain, even if it seems to be generally assumed that prolonged states of tension somehow relate to or even produce pain states in muscle. We are also unable to be specific in assumptions of which brain structures that may be involved, even if Tucker and Williamson (1984) related the tonic activation system to extrapyramidal motor control, and the phasic arousal system to pyramidal motor control. Svebak (1984) has found that personality factors may affect these two systems selectively.

In this paper we will restrict ourselves to investigating the relationships between personality, job stress, and subjectively reported muscle pain, assuming that this may be the basis for the development of pain states requiring medical attention and sick leave. We will concentrate on experienced job stress, anxiety, and defence mechanisms, since these factors seems to be essential for all psychosomatic complaints, and for objective indicators of stress, including immunological changes (Ursin 1982; Ursin et al. 1984).

Material and methods

A health questionnaire was given to a population of 474 males and females, consisting of process workers in a petrochemical plant (122), office workers (70), firemen (90), subjects exposed to noise in their home environment (100), divers (29), and air pilots (63). All were in the age range from 18 to 70, restrictions on age will be discussed later.

The questionnaire was part of a general investigation of the relationships between various sources of "stress" and health. The investigation involved questionnaires, somatic investigations, and sampling of blood, urine and saliva for immunological and endocrine evaluations of "stress" levels (see Ursin et al. 1984 for details of procedures). Data were collected from process workers, office workers, firemen, noise-exposed subjects, divers and air pilots in several smaller studies. Prior to all data collection, permissions were obtained from the subjects, the administration or organization and any trade unions involved, and medical officers in companies. Confidentiality for all types of data was secured by using code only on all sheets and keeping the key to the code separate from the data. Codes were kept by the medical officer of the companies of organization, or licence was obtained and data kept according to Norwegian laws regulating all data files for data on human subjects.

The health questionnaire consisted of questions regarding 27 common somatic and psychological symptoms. Each symptom was scored for occurrence during the last month, graded for severity (none, some, much, or severe), how many days it lasted, and if the subject had to be absent from work or had to visit a doctor. They were also asked for the occurrence of each complaint over the last three years, and if it had ever occurred.

The psychological questionnaires included a Norwegian translation of the "Life Style Index" (Plutchik et al. 1979), consisting of 92 items ("True" vs "False" statements). Scores were made for eight subscales of psychological defence mechanisms (Denial, Repression, Regression, Compensation, Projection, Displacement, Intellectualization, and Reaction Formation). The overall sum of defence mechanisms (LSI Sum) was also used. Anxiety was assessed by the Spielberger Trait Anxiety Inventory (Spielberger et al. 1970), also translated into Norwegian. This test consists of 20 statements. Finally, we will report data from a Job Stress Questionnaire (Cooper 1981) for some of the groups.

Data were analyzed with a Sperry Univac 1100 computer with standard programmes from the SPSS-X package (1983). Skewness above 2 was corrected for a few variables by ascribing to them values corresponding to no more than 3 standard deviations above the mean. For the factor analyses principal components were used for the selection of factors, Kayser-Meyer-Olkin's test for inclusion and Bartlett's sphericity test were considered. Scree-plots of Eigenvalues were inspected for decisions on factors. The factor scores were calculated by regression.

For multiple regression "forward entry" was used, and, for inclusion, variables were evaluated for significant contributions to the equations. Adjusted R squares were used in order to control for the number of individuals and variables in the final equation (Norusis 1985).

Results

Factor analysis of the health questionnaire

A Varimax rotation of data for problems last month yielded no obvious solution based on the "elbow criterion", from the second factor onwards there was a rather smooth and gradual decline in Eigenvalues. Based on Eigenvalues above 1, a nine factor solution was chosen, yielding nine orthogonal (independent) factors. Factor 1 related to anxiety and depression, Factor 2 related to cardiac problems, Factor 3 to gastrointestinal problems, and Factor 4 involved pain in the neck, pain in the back, pains in arms and shoulders, and migraine (see Table 1). This fourth factor relates to the problems treated in this paper. Migraine also loads on a separate headache/migraine factor (Factor 7); this will be regarded as a separate problem and not treated here. The other factors, explaining less of the variance, included respiratory symptoms, constipation, diarrhoea and skin problems.

The interpretation of this analysis is that common health problems as they really occur in the population are distributed over a wide range of organ systems. They "cluster", i.e. occur together, in relationships ("factors") that are clearly tied to different organ systems. It should be noted that these factors are independent ("orthogonal"), a person with complaints in one organ system may or may not have symptoms from other organ systems. In other words, it is not possible to predict from the prevalence within one system the prevalence in other organ systems. Problems related to the gastro-intestinal tract split into several independent factors, but the muscle pains cluster in one rather general factor. This means that individuals with pains in one part of this system tend to have symptoms or discomfort also in other parts of their musculo-skeletal system. The only exception is headache, which loads on a special factor (Factor 7) together with migraine. Migraine, on the other hand, loads also on the general muscle pain factor.

This study also shows that musculo-skeletal

Table 1. Factor analysis for health symptoms

	1	2	3	4	5	6	7	8	9
Anxiety	0.78								
Depression	0.73								
Palpitations	0.57								
Hot spells	0.52	0.38							
Dizziness	0.46								
Breathing problems		0.70							
Sleep problems		0.56							
Pain in the feet		0.55							
Pain in the chest	0.31	0.53	0.32						
Pain in arms/shoulders		0.49		0.45					
Tiredness	0.31	0.38							
Acid stomach, heartburn			0.77						
Sinking feeling			0.76						
Gastric catarrh or ulcer	0.38		0.50						
Back pain				0.74					
Neck pain				0.69					
Asthma					0.82				
Cough/bronchitis					0.63				
Constipation						0.76			
Troubled with gas						0.52			
Stomach ache						0.43		0.39	
Migraine				0.41			0.82		
Headache							0.62		
Lax bowels/diarrhoea								0.71	
Cold/influenza				0.41				0.42	
Eczema									0.79
Alleric skin rash					0.48				0.59

Table 2. Self reported muscle pain last month, prevalence

	N	Not affected %	At least some affected %	Significantly or seriously affected %	Seriously affected %
Total	386	58.3	41.7	18.2	3.1
Sex					
Women	37	45.9	54.1	16.7	8.3
Men	349	59.6	40.4	18.3	2.6
Living area (men)					
Urban	141	49.6	50.4	27.0	3.5
Rural	145	59.3	40.7	16.6	2.8
Occupational group (men)					
Firemen	90	45.6	54.4	30.0	4.4
Process workers	89	52.8	47.2	20.2	4.5
Office workers	56	69.6	30.4	10.7	0
Air pilots	63	82.5	17.5	3.2	0
Divers	25	64.0	36.0	20.0	0
Noise exposed	26	50.0	50.0	23.1	3.8

problems rank as one of the most important sources of discomfort in the general population. The discomfort panorama differs from the usual medical picture of health problems in an industrialized society. This panorama, again, depends on whether one considers these problems as a general practitioner, or as a hospital doctor. The picture offered by our data is probably closest to the reasons given for self-reported absence from work, but we have no statistics available on this. The leading discomfort factors are anxiety, sleep disturbance and muscle pain as well as problems from the gastro-intestinal tract. The importance of these factors requires a prevalence study, taking the degree of discomfort into consideration.

Prevalence of muscle pain

Table 2 shows the prevalence of the musculoskeletal pain factor from 386 individuals, from the same material as in Table 1, 37 women, 349 men, from process workers, office workers, firemen, noise-exposed subjects, divers, and air pilots. All individuals accepted for this analysis worked outside their homes, and were less than 60 years old. The prevalence of this factor depends on the degree of the complaint. For the last month, 54% of the women and 40% of the men in these health surveys reported some form of muscle pain in the neck, back and/or shoulders. If asked only about serious complaints, the numbers shrank to 8% for the women and 3% for the men.

There were tendencies for increasing complaint with increasing age. The difference between occupational groups is more impressive. The firemen had more complaints than any other group; except for the serious complaints, these were in the same range as for process workers. To examine if there were any significant differences in reported pain, analyses of variance were conducted. Complaints about pain in the neck, back, shoulders/arms, and a sum index for muscle pain were used as dependent variables, while sex, living area, and occupational groups were used as independent variables. Women (see Table 3) report significantly higher levels of neck pain than men. Reported back pain is highest in the urban populations. All four dependent variables show significant group effects.

Multiple regression studies of psychological determinants of muscle pain

The importance of the psychosocial factors for the subjective reports of muscle pain has been tested in a series of regression analyses of the same material as in Tables 2 and 3.

Anxiety and psychological defence were used as independent variables. For firemen, process workers, office workers and divers, the job stress index was included. Subjectively felt health complaints in the last month, the last 3 years, and if it ever had occurred, were used as the dependent variable. The results were the same, in principle,

Table 3. Means and standard deviations for muscle pain last month, by sex, and by living area and occupational group for men

	Neck			Back			Shoulders/arms			Muscle index		
	$\bar{X}$	SD	Sign. level	$\bar{X}$	SD	Sign. level	$\bar{X}$	SD	Sign. level	$\bar{X}$	SD	Sign. level
Sex			*									
Women	0.54	0.84		0.47	0.74		0.19	0.40		0.40	0.50	
Men	0.30	0.66		0.39	0.74		0.22	0.55		0.30	0.49	
Living area												
(men only)						**						
Urban	0.38	0.73		0.59	0.87		0.26	0.59		0.41	0.55	
Rural	0.32	0.68		0.31	0.68		0.25	0.59		0.29	0.48	
Occupational												
group (men only)			**			***			*			*
Firemen	0.48	0.82		0.62	0.88		0.32	0.65		0.47	0.60	
Process workers	0.38	0.76		0.36	0.74		0.29	0.64		0.34	0.52	
Office workers	0.21	0.53		0.23	0.57		0.19	0.48		0.21	0.41	
Air pilots	0.08	0.27		0.13	0.38		0.06	0.30		0.09	0.23	
Divers	0.16	0.47		0.44	0.76		0.20	0.58		0.27	0.47	
Noise exposed	0.27	0.53		0.62	0.94		0.08	0.27		0.32	0.41	

* $p<0.05$ ** $p<0.01$ *** $p<0.005$

Table 4A. Results from regression analysis where self-reported muscle pain last month in neck, back, shoulders/arms plus the muscle index are used as dependent variables. Anxiety, defence and job stress are used as independent variables

Group	Dependent variable	Adjusted R square	Sig. level of F	Correl.	Independent variables
Woman, total	Back	0.15	0.01	0.42	Compensation
		0.29	0.00	÷0.33	Intellectual.
Men, total	Neck	0.03	0.00	0.17	Anxiety
		0.04	0.00	0.15	Projection
	Back	0.02	0.00	0.16	Repression
		0.04	0.00	0.15	Anxiety
	Shoulders/arms	0.01	0.02	0.13	Projection
	Muscle index	0.03	0.00	0.18	Projection
		0.05	0.00	0.17	Anxiety
Occupational group (men):					
Firemen	Neck	0.09	0.00	0.32	Anxiety
		0.15	0.00	0.30	Compensation
		0.19	0.00	0.30	Projection
	Back	0.10	0.00	0.33	Repression
		0.15	0.00	0.26	Anxiety
	Shoulders/arms	0.04	0.04	0.22	Anxiety
	Muscle index	0.12	0.00	0.35	Anxiety
		0.17	0.00	0.31	Projection
Process workers	Neck	0.05	0.02	0.25	Reaction Formation
	Shoulders/arms	0.04	0.04	÷0.22	Anxiety
		0.07	0.02	0.06	Job stress
	Muscle index	0.04	0.04	0.22	Reaction Formation
Office workers	Neck	0.07	0.03	÷0.29	Reaction Formation
Air pilots	Neck	0.08	0.02	0.32	Repression
	Back	0.09	0.01	0.33	Intellectual.
		0.17	0.00	0.29	Repression
	Shoulders/arms	0.08	0.02	0.30	Regression
	Muscle index	0.08	0.02	0.31	Repression

Table 4B. Results from regression analysis where self-reported muscle pain in the past in neck, back, shoulders/arms plus the muscle index are used as dependent variables. Anxiety, defence and job stress are used as independent variables

Group	Dependent variable	Adjusted R square	Sig. level of F	Correl.	Independent variables
Women, total	Back	0.11	0.03	0.36	Compensation
	Shoulders/arms	0.18	0.01	0.45	Compensation
		0.26	0.00	0.44	Reaction Formation
	Muscle index	0.15	0.01	0.41	Compensation
Men, total	Neck	0.05	0.00	0.22	Anxiety
		0.07	0.00	0.19	Projection
	Back	0.03	0.00	0.17	Anxiety
		0.04	0.00	0.15	Projection
	Muscle index	0.05	0.00	0.22	Anxiety
		0.07	0.00	0.19	Projection
Occupational group (men):					
Firemen	Neck	0.12	0.00	0.36	Anxiety
		0.15	0.00	0.26	Compensation
	Back	0.04	0.03	0.23	Anxiety
	Shoulders/arms	0.06	0.02	0.26	Anxiety
	Muscle index	0.11	0.00	0.35	Anxiety
		0.14	0.00	0.25	Projection
Air pilots	Neck	0.11	0.02	0.35	Repression
Divers	Shoulders/arms	0.32	0.01	0.60	Displacement
Noise-exposed group	Neck	0.16	0.03	0.43	Anxiety
	Muscle index	0.16	0.02	0.44	Regression

for all three conditions, and we present the results for health complaints for the last month, and for ever having occurred (Tables 4A and 4B).

For women, psychological defence, especially Compensation, gave significant contributions to explained variance in complaints about back pain and pain in the shoulder and arms. The most significant relationships were found for defence mechanisms and back problems last month, and for previous trouble in the arms.

For men, taken as a whole, there was a very moderate amount of variance explained by the psychological variables. Anxiety and the defence mechanism Projection were the most relevant predictors. When the large group of men was broken down, explained variance increased, revealing different patterns for the various groups. For firemen, the group reporting most pain, Anxiety, and also Projection, contributed rather consistently to the explained variance. For health complaints last month Anxiety, Compensation, and Projection explained 19% for neck muscles, Repression and Anxiety 15% for back pain, and Anxiety alone 4% for shoulder pain.

The men exposed to noise also had high complaints, and the regression analyses showed that Anxiety explained 16% of the variance in reported neck pain in the past. In the group of air pilots, the complaint level was very low. However, for the complaints reported, defence, in particular Repression, gave significant contributions. For back pain last month Intellectualization and Repression explained 17% of the variance. For divers, a group with a moderate complaints score, the defence mechanism Displacement was the only significant predictor variable.

Complete information on age was not available for all groups (only age range, particularly for groups where personal data were particularly sensitive). However, in regression analyses where age was controlled, this variable accounted for a negligible amount of variance.

Discussion

Self-reported work stress was only moderate in the examined work groups. The job stress index did not show any predictive power in relation to muscle pain, and gave no significant contribution even for the group reporting most work related stress, the divers. However, the two occupational groups reporting most muscle pain were both shift workers (firemen and process workers).

Shiftwork may be a contributing factor to muscle pain, as has been shown for other health complaints (Gardell 1977; Cooper 1981).

The high frequency of pain in the firemen is remarkable, since the firemen are the only group that exercises every day in their working hours. The moderate pains may simply be related to their training. On the other hand, they are shift workers, their work involves sudden bursts of very strenous physical work without any "warm-up" (except for the fire itself), and they also have heavy physical loads in their extra duties as ambulance personnel. They also have complaints about the psychological aspects of their working conditions.

The psychological variables were the most consistent predictors for muscle pain in firemen. As for men as a whole, anxiety was the best predictor. In addition, use of defence was related to muscle pain among men, but the specific mechanism involved varied from group to group and no specific mechanism could be discerned as generally most important. Women were more affected by muscle pain than men, and psychological variables explained more of the variance in this factor for women than for men. High defence was related to muscle pain.

The prevalence of serious muscular discomfort in our subjects seems to correspond to recent data from the Canadian Health Survey (Lee et al. 1985). Our own material does not deal with pathology in the strict sense. We have dealt with normal physiological and psychological responses in healthy individuals. Our subjects have not approached the medical service for their discomfort in the majority of cases. The main question is whether or not these states of muscular discomfort are precursors of musculo-skeletal injuries, and to what extent psychological factors contribute to discomfort, pain, and possibly muscle injury.

The discomfort itself may result from psychological factors. In our material there is at least some influence of psychological factors at all levels of complaint. It seems reasonable to assume that the mediating psychophysiological variable is muscle tension. Prolonged muscle tension has been causally related to the development of muscular discomfort in a number of studies (Kilbom et al. 1983; Kuorinka 1983).

Musculo-skeletal injuries, often referred to as primary fibromyalgia (PF) syndrome, have been associated with abnormal psychological changes in the Minnesota multiphasic personality inventory (Ahles et al. 1984; Wolfe et al. 1984). Elevated scale scores have been found for hypochondriasis, depression, and hysteria (neurotic scales). In a smaller set of material, Clark et al. (1985) did not find any statistical significant deviation in their 22 PF patients. The material of Ahles and Wolfe might be secondary to the PF state itself. For the "normal" individuals with the "normal" complaints in our material the important psychological factors are not necessarily related to psychopathology. Anxiety, for instance, may be a normal psychological response to a difficult situation, for instance the pain itself. There is, therefore, a possibility of feedback loops, or "vicious circles". This makes it difficult or meaningless to discuss which variables determine which, as is the underlying hypothesis for a regression type of analysis. However, it also raises interesting possibilities from a therapeutic point of view. Improved muscle state may improve the psychological state, and vice versa.

The groups we have studied are not particularly exposed to high physical work load. In contrast, a group of 201 seamstresses producing thermal clothing had a yearly prevalence of muscular discomfort of more than 90%, with 40% consulting a general practioner for this problem in the last 12 months before the interview (Westgaard and Jansen, unpublished). Such numbers seem primarily due to the physical working conditions, with psychogenic factors probably contributing little to over-all tension development. However, psychogenic tension development may, according to our theoretical position, affect any individual and therefore be a larger over-all contributor to feelings of muscular discomfort for the total population than adverse working conditions generating high prevalence rates in smaller groups. Non-physical aspects of the work load may also be important. Specific work tasks may result in a general, high tension level due to arousal or attention effects. In work situations where the individual has little control over the situation, and the work pace is imposed on the subject, psychological factors may indeed interact with the physical load, or be the most important load factor (Gardell 1977; Karasek 1979; Ursin 1980).

When subjects learn that they are able to handle and control an otherwise dangerous and threatening situation, the general "activation" level (endocrine and vegetative activity) is reduced (Ursin 1978). This may also be evident in muscle tension. A reduction in physiological consequences of activation is assumed to be due to "coping", the acquisition of a "positive response outcome expectancy" (Bolles 1972; Ursin 1986).

The activation reduction is not directly related to performance, but to the acquisition of an expectancy. It is the general, tonic activation in the non-coping subject which is supposed to produce pathophysiology if sustained over time (Ursin 1980), possibly also for muscles. Only sustained tonic activation should be related to the development of pain states in the muscles. The high prevalence of muscle pain, and other complaints, in shift workers, may be due to disturbed sleep and rest cycles, which yield a more "sustained" activation level. Task oriented phasic activation may even have beneficial effects on muscle state and resistance to the development of pain.

Acknowledgements. The research reported here was supported through grants by the Royal Norwegian Research Council for Science and Industrial Research. The authors are indebted to Anne Beth Grøndahl and Geir Skauli for the Varimax solution of the data from the Health Questionnaire.

References

Ahles TA, Yunus MB, Riley SD, Bradley JM, Masi AT (1984) Psychological factors associated with primary fibromyalgia syndrome. Arthrit Rheum 27:1101—1106

Anisman H, Zacharko M (1982) Depression: The predisposing influence of stress. Behav Brain Sci 5:89—137

Balshan ID (1962) Muscle tension and personality in women. Arch Gen Psych 7:436—448

Bolles RC (1972) Reinforcement, expectancy and learning. Psychol Rev 79:394—409

Clark S, Campbell SM, Forehand ME, Tindall EA, Bennett RM (1985) Clinical characteristics of fibrositis II. A "blinded" controlled study using standard psychological tests. Arthrit Rheum 28:132—137

Cooper CL (1981) The stress check. Prentice Hall, New York

Coover G, Ursin H, Murison R (1983) Sustained activation and psychiatric illness. In: Ursin H, Murison R (eds) Biological and psychological basis of psychosomatic disease. Pergamon Press, Oxford

Eason RG, White CT (1961) Muscular tension, effort, and tracking difficulty: Studies of parameters which affect tension level and performance efficiency. Perc Mot Skills 12:331—372

Evarts EV, Shinoda Y, Wise SP (1984) Neurophysiological approaches to higher brain functions. Wiley & Sons, New York

Gardell B (1977) Psychological and social problems of industrial work in affluent societies. Int J Psychol 12:125—134

Henry JP, Meehan JP (1981) Psychosocial stimuli, physiological specificity and cardiovascular disease. In: Weiner H, Hofer MA, Stunkard AJ (eds) Brain, Behav Bodily Dis. Raven Press, New York

Hockey GRJ (1986) A state control theory of adaptation to stress and individual differences in stress management. In: Hockey GRJ, Gaillard AWK, Coles MGH (eds) Energetics and human information processing. M Nijhoff, Dordrecht

Jacobson E (1938) Progressive relaxation. University of Chicago Press, Chicago

Karasek RA jr (1979) Job demands, job decision latitude, and mental strain: Implications for job redesign. Adm Sci Quart 24:285—308

Kilbom Å, Gamberale F, Persson J, Annwall G (1983) Physiological and psychological indices of fatigue during static contractions. Eur J Appl Physiol 50:179—193

Knardahl S, Ursin H (1985) Sustained activation and the pathophysiology of hypertension and coronary heart disease. In: Orlebeke JF, Mulder G, van Doornen LJP (eds) Psychophysiology of cardiovascular control. Plenum Press, New York

Kuorinka I (1983) Subjective discomfort in a simulated repetitive task. Ergonomics 26:1089—1101

Lee P, Helewa A, Smythe HA, Bombardier C, Goldsmith CH (1985) Epidemiology of musculoskeletal disorders (complaints) and related disability in Canada. J Rheumatol 12:1169—1173

Malmo RB (1957) Anxiety and behavioral arousal. Psychol Rev 64:276—287

Malmo RB, Davis JF (1956) Physiological gradients as indicants of "arousal" in mirror tracing. Can J Physiol 10:231—238

Moruzzi G, Magoun HW (1949) Brain stem reticular formation and activation of the EEG. Electroenceph Clin Neurophysiol 1:455—473

Murison R, Isaksen E (1983) Biological and psychological basis of gastric ulceration. In: Ursin H, Murison R (eds) Biological and psychological basis of psychosomatic disease. Pergamon Press, Oxford

Norusis MJ (1985) SPSS-X. Advanced statistics guide. McGraw-Hill, New York

Plutchik R, Kellerman H, Conte HR (1979) A structural theory of ego defenses and emotions. Izard C (ed) In: Emotions in personality and psychopathology. Plenum Press, New York, pp 229—257

Pribram KH, McGuinness D (1975) Arousal, activation, and effort in the control of attention. Psychol Rev 2:116—149

Rechtschaffen A, Kales A (1968) A manual of standardized terminology, techniques and scoring system for sleep stages of human subjects. Public Health Service, US Governmental Printing Office, Washington DC

Spielberger CD, Gorsuch RL, Lushene RE (1970) STAI manual for the State-trait anxiety inventory "Self-Evaluation Questionnaire". Consulting Psychologists Press, Inc, Palo Alto

SPSS-x user's guide (1983) USA

Svebak S (1984) Active and passive forearm flexor tension patterns in the continuous perceptual-motor task paradigm: The significance of emotion. Int J Psychophysiol 2:167—176

Tucker DM, Williamson PA (1984) Asymmetric neural control systems in human self-regulation. Psychol Rev 91:185—215

Ursin H (1978) Activation, coping and psychosomatics. In: Ursin H, Baade E, Levine S (eds) Psychobiology of stress. A study of coping men. Academic Press, New York, pp 201—228

Ursin H (1980) Personality, activation and somatic health. A new psychosomatic theory. In: Levine S, Ursin H (eds) Coping and health. Plenum Press, Oxford, pp 259—279

Ursin H (1982) The search for stress markers. Scand J Psychol [Suppl] 1:165—169

Ursin H (1986) Energetics and the self regulation of activation. In: Hockey GRJ, Gaillard AWK, Coles MGH (eds) Energetics and human information processing. M Nijhoff, Dordrecht

Ursin H, Mykletun R, Tønder O, Værnes R, Relling G, Isaksen E, Murison R (1984) Psychological stress-factors and concentrations of immunoglobulins and complement components in humans. Scand J Psychol 25:340—347

Westgaard RH, Bjørklund R (1988) Generation of muscle tension additional to postural muscle load. Ergonomics (in press)

Wolfe F, Cathey MA, Kleinheksel SM, Amos SP, Hoffman RG, Young DY, Hawley DJ (1984) Psychological status in primary fibrositis and fibrositis associated with rheumatical arthritis. J Rheumatol 11:500—506. Manenica I (eds) The ergonomics of working postures. Models, methods and cases. Taylor & Francis, London, pp 3—18

Accepted August 14, 1987