Simple assessment of work health risk factors

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Abstract

Objective: Evaluation of resting Pressure Pain Sensitivity (PPS) on the sternum was used as a measure for persistent stress against physiological and subjective health variables which are relevant for the working ability.

Method: A prospective hypothesis testing study in 31 young healthy students.

Results: PPS correlated significantly to resting Blood Pressure (p=0.006), work of the heart calculated as the Pressure-Rate-Product (p=0.041), SF-36 scale for general health (p=0.0005), mental health (p=0.02), social functioning (p=0.0003), role-emotional (p=0.044) as well as SF-36 mental component summary (p=0.028), sick leave (p=0.002), clinical stress signs (p=0.0005), while no correlation was found to subjective stress evaluations (p> 0.1).

Conclusions: PPS was found to correlate to health variables associated with persistent stress. The results indicate that measurement of PPS may be useful as a tool for assessment of health risk factors.

Introduction

Stress is developing into a 21th century epidemic. It is not only a threat to the health of the individual but also of great concern for societies as a whole, affecting the productivity as well as the economy (1).

Stress may be pleasant, but also unpleasant and sometimes dangerous to life (2). It is essential to distinguish between two forms of stress: transient (acute) and persistent (chronic) stress. Transient stress is a physiological state of preparedness, engaging the entire organism, and automatically (and often unconsciously) induced through neural/hormonal signals from the brain when a threat or work challenge is perceived. Thus it serves as a defence mechanism and helps to increase performance level whether this is to be used in a fight/flight situation or to solve a job task. When the threat/challenge is over, homeostasis is re-established. This adaptive ability associated with transient stress is allostasis (3). In contrast, persistent stress occurs due to a prolonged exposure of the hormones involved in transient stress, which gradually deteriorates the adaptive ability and subsequently causes psychological and physiological dysfunctions that may be harmful to health. This gradual loss of adaptive capacity is called allostatic load (4). The level of stress depends on the individual perception of the balance between environmental demands/ the expectancies of the outcome of the stimulus and the resources available/adaptive capacity of the individual.

Persistent stress is suspected to be a pathogenetic factor in the Metabolic Syndrom (2, 5). Metabolic syndrome affects approximately 40 million Americans and comprises abdominal obesity, insulin resistance/diabetes 2, hypertension and dyslipidemia, all of which are risk factors for cardiovascular disease and premature death (6).

Internationally, no current consensus exists on how to diagnose stress biochemically. (7)(8). It is difficult to identify a single physiological stress measure because of individual differences in perceptions and physiological response patterns (9). Because stress involves 1) objective environmental stimuli, 2) individual perceptions and data processing, as well

as 3) psychological and 4) physiological responses. Indicators for each of these four factors have been used to asses stress. The assessment may be further complicated by the fact that these stress markers may not be present simultaneously.

On this background we searched for a simple objective and reliable measure of stress. In a previous study, we have found the application of the Pressure Pain Sensitivity of the sternum (Ull measure) useful as a measure of stress (10). In continuation of this, the aim of the present study was to evaluate the use of the Ull measure as a prognostic risk assessment tool with respect to work related health variables, such as sick leave, general physical and mental health, social function and clinical signs of persistent stress with respect to performance.

Material and Methods

Subjects

31 healthy, working opera singing students, age 24-35 years, 18 females and 13 males. 10 females and 8 males were measured twice during 6 month (winter and summer); the rest was just measured once as a second measurement was not possible.

Effect variables

The SF-36 questionnaire is used to identify health parameters. SF-36 is a multi-purpose, short-form health survey with 36 questions. It yields an 8-scale profile of functional health (mental and physical), well-being and social function. SF-36 has been translated in more than 50 countries as part of the International Quality of Life Assessment (IQOLA) Project. SF-36 is a widely used international questionnaire for general physical and mental health (11).

SF-36 terminology:

Physical functioning (PF): physical function and physical activity; Role-Physical (RP): reduction in activity due to physical health; Body Pain (BP): reduction in well-being and physical activity due to physical pain; General Health (GH): general health physically and mentally: personal view of general health, physical and mentally; Vitality (VT): physical and mentally well-being; Social Functioning (SF): reduction in activity, physically and mentally; Role-Emotional (RE): reduction in activity due to mental health; Mental Health (MH): mental function and well-being; Physical component summary (PCS) & Mental component summary (MCS).

Clinical stress symptoms

In a questionnaire participants were asked about the occurrence of 52 clinical stress symptoms.

Subjective assessment of stress level

On a four step ordinal scale from no stress to maximum stress, with respect to estimation of 1) the present level and 2) an average from the last 3 months.

Sick leave

The sicknesses leave registered as days absent per month from any cause. The data was provided as a write-out of the registration sheet for the school, in which the presence/absence of each student is recorded on a daily basis. Sick leave load factor is calculated as the number of day's absence/person/3months.

Physiological variables:

PPS on the sternum was measured by the Ull meter®; Noxious withdrawal reflex (NWR) was observed as involuntary muscle contractions in the regions of eyes, cheeks (=startle reflex) or in the flexor muscles of the neck and upper extremity, for a group NWR is calculated as the frequency of observed reflex in %; Body Mass index (BMI); Waist-hip ratio; Blood pressure measurements after 10 minutes of rest in horizontal position;

Pressure rate product at rest (PRP = systolic blood pressure * heart rate); Middle blood pressure (MBP =2/3*diastolic blood pressure + 1/3*systolic blood pressure).

The use of blood pressure as a marker for persistent stress is based on the association between persistent stress as a pathogenetic factor in Metabolic Syndrom (2, 5). Furthermore, in a 30 year observational case control study is has been found that the increase in blood pressure with increasing age, has been found to be related to persistent stress (12).
The resting heart rate has been found to have prognostic value in ischemic heart disease (13, and the common nominator being sympathetic tone (14). The pressure-rate-product is the product of systolic blood pressure and pulse rate. In cardiology it serves as a practical index for myocardial oxygen update and thus reflects cardiac work. It is mainly controlled by beta-adrenergic catecholamines (15) and as such it is a suitable marker for changes in sympathetic tone of the heart (8) and has been found an useful prognostic marker for ischemic heart disease (16). In a previous study, we have found a significant correlation between resting heart rate, PRP and the PPS on the sternum (10). Thus the use of resting heart rate and PRP are included in the present study.

Blood pressure (mm Hg) and heart rate (HR, beats/min) were recorded by Thuasne automatic blood pressure monitor, model W0840 002 001 (Microlife ref. BP-3AA1-2, BP 243 - 92307 Levallois-Perret Cedex, France). For analysis, the mean of two consecutive measurements was used.

Measurement of Pressure Pain Sensitivity: Pressure pain sensitivity of nociceptors on the sternum was recorded using the Ull meter. The subjects were placed in supine position, and each measurement started with two measurements on the control point, the dorsal part of the middle phalanx on the left index finger, during which the technique and procedure was introduced. The measuring device (Ull meter) was applied with a gradually increase of pressure, in total allowing 3-4 seconds pressure time. The subject was

instructed to say “Stop” as soon as discomfort was felt. If the researcher observed a withdrawal reflex, typically the startle reflex from the eyes, this was considered as a stop signal as well. Subsequently, measurements on the sternum were conducted following the same procedure. The point for measuring (active point) was identified by palpation of the observer as the most tender point of the skin on the sternum within the area between the third, fourth and fifth intercostal space, reflecting the area of segmental innervations of the heart (17). The mean of at least two consecutive measurements were used. The subjects were able to do self-measurements. In previous studies we have demonstrated, that the Ull measurement performed by health-professionals has a high precision, $r= 0.97$, $p< 0.0001$, $n=181$ repeated measurements, as well as when performed by Non-professionals: $r= 0.95$, $p< 0.0001$, $n=33$ (10).

PPS and health risk factor analysis

We wanted to test the association between the Ull measure and the probability of an elevated risk factor. In order to do so, the following discrimination values were used: Resting systolic blood pressure: 130 mm Hg, resting diastolic blood pressure: 85 mm Hg, Resting middle blood pressure: 100 mm Hg; resting pulse rate: 75 beats/min; resting work of the heart (PRP): 10.000 mm Hg x beats/min; SF 36 scales: the mean for the general Danish population matched for age and sex (11). With respect to clinical stress signs, the discrimation point is based on clinical experience from 400 observations in healthy working people (unpublished data)

Results

Resting values of PPS on the chest bone correlated significantly to resting Blood Pressure (correlation coefficient $r = 0.37$, $p = 0.006$), resting work of the heart calculated as the Pressure-Rate-Product ($r = 0.27$, $p = 0.04$), noxious withdrawal reflex ($r = - 0.54$; $p = 0.002$), SF 36 scales for general physical and mental health and social function (both $p = 0.0005$), sick leave from any cause ($r = 0.54$, $p = 0.002$), clinical stress signs ($r = - 0.53$, $p = 0.0005$)(table 1), while no correlation was found to subjective stress evaluations ($p > 0.1$). The likelihood of an elevated health risk factor among patients with different PPS

levels, with a 100% increase in pain sensitivity separating each group is shown in Table 2; for example the likelihood for an elevated systolic blood pressure double up between each group; i.e. the probabilities are 1,2 and 4 for PSS <= 30, 30 < PPS <= 60, PPS > 60, respectively. Similarly, the probabilities are 1, 5, and 9 for work of the heart (PRP); 1,2 and 4 for SF 36 Mental component summary, and 1, 7 and 24 for sick load factor (see table 2).

Discussion

The present study indicates that the PPS (Ull measure) as used in this study is correlated to a variety of work related health factors, such as sick leave, physiological signs of persistent stress, general mental and physical health, social function, and known risk factors for development of cardiovascular disease.

A meta-analysis of 485 studies with a combined sample of 270.000 individuals found that correlation across all health measures to job satisfaction was r = 0.3, and concluded:

"That job satisfaction level is an important factor influencing the health of workers. Organisations should include the development of stress management policies..." (18).

In the present study we find that a high PPS on the chest bone is associated with an increase in risk factors related to cardiovascular disease, and deteriorated general physical and mental health as well as a reduced social function, when measured by the SF 36 questionnaire.

A causal association between prolonged stress and an increased incidence of ischemic cardiovascular disease is suspected (2, 5, 19, 9). Resting heart rate, blood pressure and the work of heart measured as the double-product have all been found to be useful variables in stress-related conditions and prognostic indicators of cardiovascular disease

(5, 13, 16). The SF 36 Questionnaire has been found useful in assessing the quality of life as well as a prognostic tool in patients with ischemic heart disease (20, 21, 22).

We found that the Ull Measure was linked to SF 36 as well as to sick leave from any cause. In other studies SF 36 was found useful in the assessment of the long term health related effects from work related stress in 10.000 British workers (23), and poor mental health assessed by SF 36 was strongly associated with intention to retire early from work among 5.000 Finish workers (24). Furthermore, SF 36 has been found associated with return to work after burn injury (25), radius fracture (26) and abnormal uterine bleeding (27).

Three conditions, all having a high prevalence in the Western countries and a high impact on the working ability, have been found closely linked to sensory hypersentivity: Irritable bowel syndrome, migraine and non-malignant chronic pain.

Irritable bowel syndrome (IBS) is one of the most common functional gastrointestinal disorders, characterized by abdominal pain and disturbed defecation that cannot be explained by structural abnormalities, and with an estimated prevalence rate in the general population of 10-15% in industrialised countries. Although IBS is not a life-threatening disease, it contributes significantly to a large segment of healthcare resource consumption (28). It has a strong impact on the work ability of the person, and the condition is highly influenced by stress, which leads to increased visceral sensitivity of specific polymodal sensor cells of the intestinal wall (29) , similar to those cells of the skin of the sternum used for the Ull measure. For such patients, a close relationship between job strain, SF 36 measured health and sick leave has been observed (30).

For migraine, the prevalence in Western countries is approximately 10 % (31) among the adult population, leading to a big impact on the work force ability. Among these patients enhanced sensitivity to pain has been observed (32) as well as increased sensitivity to stress and with prolonged recovery period, when exposed to stress (33). In migraine patients, quality of life, measured by SF 36, has been found to be significantly deteriorated (34, 35, 36).

For chronic non-malignant pain (defined as pain for more than 6 months) the prevalence in the Danish population is 19%, indicating that approximately 1 million Danes have chronic pain (37). Experimental studies have shown than in such chronic pain patients pressure pain sensitivity in general is increased with a corresponding decrease in quality of life, measured by SF 36 (38, 39).

We found an exaggerated noxious withdrawal reflex and startle reflex when the Ull measure was elevated in this study as well as in the previous study (10). The clinical use of the noxious withdrawal or startle reflex for diagnostics is already established as an exaggerated startle reflex is part of the criteria for Post-traumatic-stress-syndrom (PTSD) (40). Furthermore, an enhanced startle reflex has been found a significant predictor for relapse in alcoholics (41), supporting the link between persistent stress and addiction (42).

The limitations of this study are the small number of subjects and potential confounding factors. Possible observer bias has been taken into account by applying blinded measurements: The Ull measure conducts blinded measurements, and blood pressure and pulse measurements were recorded by automatic equipment. Height and weight was carried out by a separate research team. Results from questionnaires were not known to the researcher at the time for their measurements. The subjects were told not to smoke tobacco, drink coffee or alcohol, take medication or do heavy physical exercise two hours prior to the examination.

We found no correlation between the Ull measure and the subjective assessments of stress. Although most of us in our daily life trust our own judgement of stress, researchers have not been able to confirm that (8;9), as a major part of the physiological stress response may run unconsciously and according to a dose-response pattern similar to that of pharmaceutics (43; 44). In this sense the finding of a logistic correlation between the Ull measure and the various health variables is in line with such a dose-response pattern. The lack of connection between the Ull Measure and subjective stress assessment, underlines the need for easy-to-use and reliable tools for stress measurement. However, before introduced to the general consumer, evidence based intervention modalities must be at hand in order to prevent worry in case of a high Ull measure. This represents a potential next step in the development of the technology together with tests of compliance for everyday use.

We conclude that PPS on the sternum is linked to factors of importance to working life as well as to life in general. As the measurement is simple and reliable, it may have a broad range of implications in the working life environment, not only in the assessment of the potential stress load from the working environment, but also to distinguish between work-life and private-life related stress, by measurement at different times. The potential use as part of a feedback guided stress management program represents another potential application of the technology.

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Table 1. Correlations between PPS and health risk factors.

Parameter tested for correlation to PPS	**Spearman´s rho non-parametric test**	
	R	p (one-tailed)
noxious withdrawal reflex	-0,543	0,002
SF-36 GH	-0,575	0,0005
Sick leave	0,542	0,002
Clinical stress symptoms (number)	-0,528	0,0005
SF-36 (SF)	-0,442	0,0003
Diastolic blood pressure	0,449	0,002
Finger_PPS	0,407	0,022
SF-36 (MH)	-0,339	0,020
Middle blood pressure (MBP)	0,374	0,006
SF-36 (RE)	-0,284	0,044
SF-36 (MCS)	-0,326	0,028
Systolic blood pressure	0,258	0,045
Heart rate product (PRP)	0,265	0,041

Table 2. Calculated increase in probability of elevated physiological or health factor, as a function of the PPS measurement on the sternum. The probabilities are calculated, using the probability for student with a PPS < 30 as baseline value = 1. (n=42)

Health risk factor	**PPS <=30**	**30 < PPS <= 60**	**PPS < 60**
Systolic blood pressure	1	2	4
Diastolic blood pressure	1	3	7
Middle blood pressure (MBP)	1	4	7
Heart rate	1	6	7
Heart rate product (PRP)	1	5	9
Clinical stress symptoms (balanced)	1	2	5
SF-36			
Mental component summary (MCS)	1	2	4
General health (GH)	1	33	39
Vitality (VT)	1	2	3
Social functioning (SF)	1	10	14
Role-emotional (RE)	1	5	10
Mental health (MH)	1	4	4
Sickness leave, load factor	1	7	24
Noxious withdrawal reflex	1	19	38