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PSYCHOPHYSIOLOGICAL STRESS IN HIGH SCHOOL TEACHERS

TIINA RITVANEN[1], VEIKKO LOUHEVAARA[1], PERTTI HELIN[1], TOIVO HALONEN[2] and OSMO HÄNNINEN[1]

[1] Department of Physiology
University of Kuopio
[2] Department of Clinical Chemistry
Kuopio University Hospital
Kuopio, Finland

Abstract
Objectives: The aim of this study was to follow psychophysiological stress over a year with four repeated measurements in full-time employed high school teachers and to compare their results with those obtained in the part-time retired teachers, gardeners and rescue workers. **Materials and Methods:** The subjects consisted of 17 (10 females, 7 males) full-time and 9 part-time employed teachers (7 females and 2 males) in three high schools, 12 female gardeners and 13 male rescue workers. The data on job conditions, well-being, and psychosomatic symptoms were obtained by a questionnaire. The perceived stress was recorded using a visual analogue scale. The neuroendocrine reactivity was assessed by determining the diurnal urine excretion of epinephrine and norepinephrine. Electromyography of the trapezius muscle was recorded during working days in all subjects and in full-time teachers on one day in the holiday season. Blood pressure and heart rate were measured in the morning and in the afternoon. **Results:** Psychophysiological stress in the full-time employed teachers was at similar levels on all three working days in December, March and November. Recovery from psychophysiological stress of working period was observed on summer holidays. Blood pressure, static muscle tension, perceived strain, psychosomatic symptoms and epinephrine level decreased significantly during the summer holidays as compared to the working days. The full-time employed teachers reported more perceived stress and psychosomatic symptoms than the part-time retired teachers or gardeners and rescue workers. Also static muscle activity was higher in full-time teachers than in rescue workers on the working days. **Conclusions:** More emphasis should be given to prevent psychophysiolocigal stress among teachers as well as to develop stress coping methods, and part-time working systems to facilitate work ability of aging teachers.

Key words:
Teachers, Psychophysiological stress, Static muscle activity

INTRODUCTION

In Finland, teachers experience at work considerable stress that is associated with an increased frequency of somatic complaints [1,2]. Premature retirement is common among teachers and it doubled in the 1990s as compared to other occupations. Mental health problems, like burnout, are the most common reasons for premature retirement [3]. Prolonged negative stress that reflects a non-optimal psychophysiological balance gradually leads to gastrointestinal disorders [4], depression and anxiety [5] and cardiovascular diseases [6]. The endocrine and autonomic nervous system disturbances due to the prolonged negative stress and sustained psychological overload leads to the development of health complaints [7,8]. High job demands (e.g., overload, role conflict and responsibilities), lack of job autonomy and poor job satisfaction are associated with the risk of cardiovascular diseases [9,10]. When an individual is repeatedly exposed to negative occupational stress factors without recovery, a vicious spiral may develop [8].

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Address reprint requests to T. Ritvanen, MSc.Health., Department of Physiology, University of Kuopio, P.O. Box 1627, 70211 Kuopio, Finalnd (e-mail: tiina.ritvanen@uku.fi).

Psychophysiological measurements can be used to assess the interactions between work, stress, and health. Cardiovascular and neuroendocrine parameters are used in assessing human responses to various occupational stress factors [11]. Blood pressure(BP) may increase in mentally demanding tasks [12–14]. Heart rate (HR) is commonly reported to increase during situations of high muscle tension, or conversely it decreases during monotonous and low-arousal work [15,16]. In the long run, high catecholamine excretion constitutes a hazard to health and well-being. Rapid recovery to hormonal baseline reflects a good adjustment to the situation and positive feelings. On the contrary, constantly elevated catecholamine excretion is a sign of poor adjustment, associated with negative stress. Chronically increased catecholamine excretion can be due to a long-term stressful situation [17,18].

Electromyography (EMG) is used for recording activation of muscles. In addition to physical work, mental stress also increases muscle tension [19–21]. The studies of Svebak et al. [22], Lundberg et al. [23] and Waersted and Westgaard [24] showed the lack of muscular relaxation in many individuals, not only in physically demanding tasks but also in psychologically stressful situations. Psychophysiologically induced muscle tension is relatively low compared to that caused by high physical demands. However, lack of relaxation is considered to be a more important health problem than that due to the high force of high frequency of muscle contraction [25,26].

The aim of the present study was to assess the work-related psychophysiological stress in high school teachers over four key periods of one year and to compare the results of the tests obtained in the full-time teachers with those in the retired part-time teachers, rescue workers and gardeners.

MATERIALS AND METHODS

Subjects

Fifty one workers volunteered to participate in this study. The subjects consisted of 17 (10 females, 7 males) full-time and 9 part-time retired (40–70% of the full time work) teachers (7 females and 2 males) of three high schools, 12 female gardeners and 13 male rescue workers. All the subjects reported good health.

The teachers employed on a part-time basis were significantly ($p < 0.001$) older (range, 58–62 years) than the other groups (Table 1). They were also significantly ($p < 0.001$) more experienced in their work than the others. The number of sick leave days was significantly ($p < 0.001$) larger among gardeners than in other groups. There were no significant differences in smoking habit or weekly leisure time physical activity between the groups. The subjects were satisfied with their jobs. They all gave their full informed consent to participate in the study, and its protocol was approved by the Ethics Committee of the Kuopio University Hospital.

Table 1. Age, working years, health variables and job satisfied of the subjects

Background variables	Subjects: Full-time employed teachers (n = 17)	Part-time retired teachers (n = 9)	Gardeners (n = 12)	Rescue workers (n = 13)	P
Age	43 (7)	59 (1)	47 (5)	43 (6)	0.001
Working years	15 (7)	30 (2)	13 (4)	16 (9)	0.001
Absenteeism[1]	1.4 (2.)	0.56 (1,7)	25.6 (21)	1.4 (4)	0.001
Exercise activity[2]	4,1 (2)	3.7 (2.2)	4.2 (3.4)	5.2 (3.9)	0.882
Smoking[3]	10	0	50	23	0.086
Job statified[3]	83	100	75	77	0.490

Values are means (SD).
[1] Days/year.
[2] Time/week at least 30 min.
[3] Percent of subjects.

METHODS

In teachers, the study was carried out over four key periods of one year: the first measurements were done in December; the second in March when work strain tends to be highest due to the matriculation examination, the third in the holiday period in July, when work stress levels are supposed to be low. The other groups of subjects were measured on the first working day after the summer holidays. The fourth measurements were taken in October. The general protocol of the psychophysiological measurements is presented in Fig 1. The data on job conditions, well-being, and psychosomatic symptoms were obtained by a questionnaire.

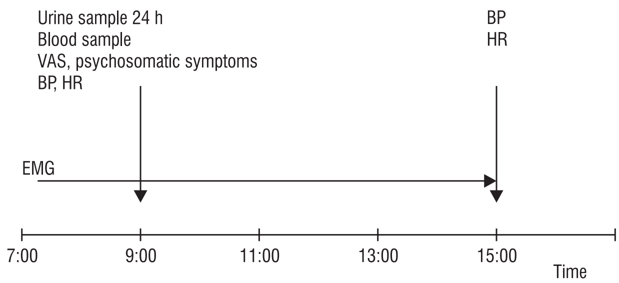

Fig. 1. General design of the study, including psychophysiological measurements. Arrows indicate when different measurements were performed. The horizontal arrow represents continuous recording (EMG). Four similar measurements were done over a period of one year.

Perceived stress

The subjects recorded their psychophysiological stress using a visual analogue scale (VAS). The results of each VAS were reported in millimeters (scale 0–100 mm, with the end points of no stress and extreme high stress) [27].

Psychosomatic symptoms

Various psychosomatic symptoms were inquired with the scale of 1–5, where "never" = 0 and "every working day" = 5. The registered symptoms were headache, tiredness, anxiety, tenseness, nervousness, depression, stomach pain, mild fever, indisposition, and exhaustion. The theoretical range of the sum – scale was 0–55.

Catecholamine excretion

Neuroendocrine reactivity was assessed by the diurnal urine excretion of epinephrine and norepinephrine in a 24-h urine collection. Urine samples were collected in polyethylene containers with 10 ml of 6 mol/L HCl as preservative and stored in a refrigerator (5°C ± 3°C) during the collection. The volume of 24-h urine was measured and 60 ml of the aliquot was frozen at -70°C until analyzed. Data on consumption of coffee, tea, nicotine and drugs during all four sampling were collected. The subjects were asked to avoid bananas, chocolate and vanilla one day before and during the diurnal urine sampling.

The chromatographic system consisted of the Shimadzu LC-10A pump (Shimadzu, Japan), Waters 717 Autosampler (Waters Inst., USA), ESA, Chromsystems HPLC column for urinary catecholamines (# 6100) (Chromsystems Instruments and Chemicals GmbH, Munich, Germany), The ESA, Coulochem II detector equipped with Guard Cell (Model 5020) and Analytical Cell (Model 5011) (ESA, Bedford, MA, USA). Mobile phase of HPLC was purchased from Chromsystems Instruments and Chemicals Glubtt (Munich, Germany). The data were analyzed by HP Kayak XA computer (Hewlett Packard, USA) equipped with HP ChemStation chromatography program. The chromatograms were printed out by HP LaserJet 4000 printer.

An aliquot of sample, standard or control (3.0 ml), was transferred to the vessel, followed by the addition of 100 μl of internal standard and 6.0 ml of dilution buffer. The diluted urine was applied to prepared clean-up columns. The effluent was discarded. Thereafter, the clean-up columns were rinsed once with one column volume of distilled water. Finally, catecholamines were eluted out of the clean-up columns with 6 ml of elution buffer. An aliquot of 20 μl was injected into the HPLC system. The absolute recovery of catecholamines was 81–87%, analytical recovery 89–102%, linear range of the method 0.06–6 nmol/l, intra-assay variation 3–5% and inter-assay variation 5–7%.

Electromyography

Electromyography was recorded from the surface of the trapezius muscle bilaterally (trapezius pars desendes) by a portable ME3000P device and analyzed by ME300P software (Mega Electronics Ltd., Kuopio, Finland). The

ME300P device enables the muscle activity to be monitored as averaged fully rectified signals from 15 to 500 Hz with the averaging period of 1 s to give root-mean-square (RMS) values [28]. The skin was cleaned with an alcohol swab before pairs of disposable surface electrodes (Ag/AgCI, type M-00-S, N-00-S Medicotest, Ölstykke, Denmark). The electrodes were attached bilaterally to the upper rim of the trapezius muscle with a 2 cm inter-electrode spacing about 2 cm lateral of the midpoint between C7 and acromion. The reference electrodes were attached to the skin approximately 9 cm laterally from the recording electrodes. The positions of the electrodes were defined according to the recommendation of Zipp [29]. The EMG activity was measured during actual work day. The EMG of the subjects being full-time teachers was also measured on one day in the holiday season.

The RMS values were normalized with a reference voluntary electrical activity obtained during a static submaximal reference voluntary contraction. The normalization values achieved in this way (100%) corresponded to about 10–15% of the maximal voluntary contraction (MVC) of the trapezius muscle [30]. EMG levels were analyzed according to the amplitude probability distribution function (APDF) introduced by Jonsson et al. [31]. From a cumulative frequency distribution, the 10th percentile was defined as the static load level, the 50th percentile as the intermittent load level, and the 90th percentile as the dynamic load level. The numbers of silent periods in EMG pattern were calculated by EMG gaps analysis. The gap threshold was defined as the mean RMS value of the best, i.e., the lowest, relaxation recordings plus 5% of the reference voluntary electrical activation of the reference contraction, corresponding to about 0.5 %MVC, and for at least 1 s long (gaps) [32].

Blood pressure and heart rate

The systolic (SBP) and diastolic blood pressure (DBP) and heart rate were measured twice a day. The first measurement was done in the morning before the work (7:00–10:00 am) and the second measurement in the afternoon (14:00–16:30 pm) when the working day was over, using an automatic digital device (Omron M4, Matsusaka Co., Ltd., Japan).

Statistical analysis

Group differences with variables characterizing the subjects were tested by one-way analyses of variance (ANOVA) and Tukey's post hoc test. Differences between gender within subjects of teacher's group for the psychophysiological stress factors were tested by repeated measures of ANOVA. Repeated ANOVA measures with four levels for each period (December, March, July, November) were conducted to assess the variation of the psychophysiological stress factors. Period differences were tested by Bonferron post hoc test, and group comparisons were tested by Tukey's post hoc test. In July, the group comparisons were not done, because of different measurement conditions of the subjects. The possibility that gender, age, group and the body mass index (BMI), calculated by dividing the body weight (kg) by the squared body height (m^2), may have exerted a differential influence on psychophysiological parameters, they were tested by (MANOVA) of repeated measures. SBP, DBP and HR differences between morning and afternoon were tested by paired sample t-test. Correlations between VAS values and psychosomatic symptoms and other variables were determined using the Pearson correlation coefficient. The differences were considered statistically significant at $p < 0.05$.

RESULTS

Visual analogue scale and psychosomatic symptoms

In the full-time teachers, the VAS was high during the three work periods in December, March and October (Table 2). During summer holidays it decreased significantly ($p < 0.001$) compared with the working months. The VAS differed significantly ($p < 0.05$) between the key periods in all other groups of the subjects except for the part-time retired teachers. The full-time teachers reported significantly ($p < 0.05$, $p < 0.01$) higher VAS values in December than the other groups of the subjects. In March and October, the VAS was significantly ($p < 0.05$) higher in the full-time teachers than in the rescue workers and gardeners. The part-time retired teachers reported the same VAS values in all four periods. The gardeners and the rescue workers showed the highest ($p < 0.05$) VAS values in December and the lowest on the first day at work after summer holidays.

Psychosomatic symptoms varied significantly between the periods in the full-time teachers and the rescue workers (Table 2). The full-time teachers reported symptoms more often than other groups of the subjects. This difference reached the level of significance ($p < 0.05$) in March compared to the rescue workers. Age and gender had no significant effect on the VAS values and psychosomatic symptoms. The VAS and the psychosomatic symptoms were significantly correlated in all four periods ($r = 0.59$, $p < 0.001$; $r = 0.55$, $p < 0.001$; $r = 0.66$, $p < 0.01$; 0.57, $p < 0.001$, respectively).

Diurnal urinary catecholamines

In the full-time teachers, diurnal urine epinephrine excretion was significantly higher in October than in July ($p < 0.05$), and in March it approached the level of significance ($p = 0.067$). In the group comparisons, the highest level of epinephrine excretion was observed in the full-time teachers in October. In March and October, the highest level of epinephrine was observed in the rescue workers (Table 3). These differences reached the level of significance between rescue workers and part-time retired teachers in March ($p < 0.05$). Diurnal urinary norepinephrine excretion differed significantly ($p = 0.04$) between four measurements in the all subjects, but within groups or between groups there were no significant differences between individual periods. Norephinephrine levels correlated positively with BMI (December, $r = 0.44$, $p < 0.001$; March, $r = 0.40$, $p < 0.001$; July, $r = 0.29$, $p < 0.01$; and November, $r = 0.30$, $p < 0.01$).

Electromyography

The EMG activity of the mean left- and right-hand sides of the upper trapezius muscle varied significantly ($p < 0.01$) between individual periods (Table 4). In the full-time teachers, the static muscle activity decreased significantly ($p < 0.05$, $p < 0.01$) during holidays as compared to the three working months (Fig. 2). EMG of the 50th and 90th percentile of APDF was, however, similar during the all four periods. The average gap duration was significantly ($p < 0.05$) longer in summer holidays than in work days in December. In the part-time retired teachers the EMG was similar to that in the full-time teachers, but the static activity tended to be lower in the three working months. In the gardeners the EMG activity levels of 10th and 90th

Table 2. Perceived stress (VAS) and psychosomatic symptoms in full-time employed teachers, part-time retired teachers. gardeners and rescue workers. Analysis of variance between periods in four repeated measurements over one year. Periods: 12 = December, before Christmas holiday; 3 = March; 7 = summer holidays of teachers and the first working day after summer holidays in the other groups; 10 = October

Group of subjects	Perceived stress (VAS, mm)					Psychsomatic symptoms (0–55)				
	Month					Month				
	12	3	7	10	P	12	3	7	10	P
Full-time employed teachers (n = 17)	63 (18)	52 (28)	15*** (20)	59 (23)	0.001	14 (8)	14 (10)	9** (10)	13 (7)	0.000
Part-time retired teachers (n = 9)	32## (28)	31 (23)	20 (21)	37 (26)	0.545	12 (6)	9 (5)	9 (5)	9 (6)	0.095
Gardeners (n = 12)	34## (22)	28 (25)	14t (11)	21## (21)	0.022	10 (7)	9 (6)	7 (7)	5 (6)	0.080
Rescue workers (n = 13)	40# (24)	24# (24)	3tt (4)	25# (23)	0.001	9# (6)	7 (6)	3 (4)	6 (4)	0.028

Values are means (SD).
Bonferroni multiple comparison between periods within group: *** $P < 0.001$ period 3 vs. other periods, ** $P < 0.01$ period 3 vs. period 1 and 2.
tt $P < 0.01$ period 1 vs. 3.
Significant difference between groups: # $p < 0.05$ teachers vs. rescue workers, ## $p < 0.01$ teachers vs. part-time retired teachers/gardeners. Tukey's multiple comparison.

Table 3. Diurnal urine excretion of epinephrine (μmol/24 h) and norepinephrine (μmol/24 h) in high school teachers compared to the levels in other groups under study

Groups of the subjects	Neuroendocrine measures	Month			
		12	3	7	10
Full-time employed teachers (n = 17)	Epinephrine	0.04 (0,02)	0.04 (0.03)	0.03 (0.02)	0.05 (0.02)
	Norepinephrine	0.29 (0.11)	0.23 (0.06)	0.23 (0.05)	0.22(0.08)
Part-time retired teachers (n = 9)	Epinephrine	0.03 (0.01)	0.03 (0.01)	0.04 (0.01)	0.04 (0.01)
	Norepinephrine	0.22 (0.10)	0.26 (0.04)	0.25 (0.06)	0.26 (0.07)
Gardeners (n = 12)	Epinephrine	0.03 (0.02)	0.27 (0.07)	0.04 (0.02)	0.04 (0.001)
	Norepinephrine	0.28 (0.07)		0.28 (0.11)	0.29 (0.06)
Rescue workers (n = 13)	Epienphrine	0.05 (0.03)	0.05 (0.02)	0.05 (0.01)	0.04 (0.02)
	Norepinephrine	0.35 (0.07)	0.33 (0.12)	0.32 (0.11)	0.31 (0.11)

Values are means (SD).
* p < 0.05 month 7 vs. 10.

percentiles of APDF were significantly (p < 0.01, p < 0.001) higher in all repeated measurements compared to other groups of the subjects.

Blood pressure and heart rate

Systolic and diastolic blood pressures lowered significantly (p < 0.05 and p < 0.01) in the full-time teachers during the holidays compared with those in October, December and March (Table 5). In rescue workers, the SBP and DBP values were significantly higher (p < 0.05 and p < 0.01) in afternoons than in mornings in December and March. HR was significantly lower (p < 0.05, p < 0.01) in the afternoons than in the mornings in the part-time retired teachers during the all four periods and in the full-time teachers

Table 4. The trapezius activity in full-time employed high school teachers compared to the values in the subjects of other groups under study. Numeric values (Mean, SD) for the 10th, 50th and 90th percentiles of the amplitude distribution of the EMG activity at standardized submaximal reference contraction (RVC), EMG gaps frequency (threshold level 5% RVC, at least 1 s duration) and average gap time over four periods: 12 = December; 3 = March; 7 = summer holidays in teachers and on the first working day after the summer holidays in the other groups; 10 = October

Group of the subjects	Month	M. trapezius				
		10th	50th	90th	EMG gap[1]	Gap duration[2]
Full-time employed teachers (n = 17)	12	5 (1)*	28 (8)	56 (12)	1.6 (0.6)	7.2 (2.2)[□]
	3	5 (1)**	27 (10)	59 (12)	1.8 (0.8)	8.4 (2)
	7	2 (1)	35 (16)	64 (19)	2.4 (0.9)	9 (2.2)*
	10	5 (1)*	32 (11)	71 (15)	1.7 (0.6)	7.8 (2)[□]
Part-time retired teachers (n = 9)	12	3 (1)	31 (14)	59 (9)	1.6 (0.7)	8.3 (3.7)
	3	3 (1)	25 (15)	52 (11)	1.9 (0.9)	8.6 (2.3)
	7	2 (1)	31 (14)	57 (15)	1.8 (0.7)	8.4 (2.9)
	10	3 (1)	28 (12)	63 (13)	1.9 (0.9)	9.2 (3.5)[§]
Gardeners (n = 12)	12	9 (2)[t]	48 (14)[t]	109 (20)[tt]	2.5 (0.7)	6.6 (2)[++]
	3	9 (3)[t]	45 (13)[t]	99 (17)[tt]	2.4 (0.7)	8 (3.5)
	7	8 (1)	43 (11)	110 (19)	2.3 (0.8)	7.2 (3)
	10	10 (2)[t]	51 (14)[t]	105 (14)[tt]	1.9 (0.7)	6.6 (2)[++]
Rescue workers (n = 13)	12	1 (1)[#]	45 (6)	65 (19)	1.7 (0.8)	8.7 (3)
	3	1 (1)[#]	40 (10)	51 (15)	1.9 (0.6)	10 (3.3)
	7	1 (1)	38 (13)	59 (15)	1.6 (0.6)	10.7 (4)
	10	1 (1)[#]	47 (8)	57 (19)	1.6 (0.6)	9.5 (1.7)

[1] No. of gaps per min.
[2] Average gap duration in s.
Significant period difference within groups: * p < 0.05 7 vs. 12 and 10, ** p < 0.01 7 vs. 3, Bonferroni post hoc test.
Significant group difference: [□] p < 0.05 teachers vs. rescue workers, [§] p < 0.05 part-time retired teachers vs. gardeners, [t] p < 0.01 gardeners vs. teachers and part-time retired teachers, [tt] p < 0.001 gardeners vs. other groups, [++] p < 0.01 gardeners vs. rescue workers, [#] p < 0.01 rescue workers vs. other groups, Tukey's multiple comparison.

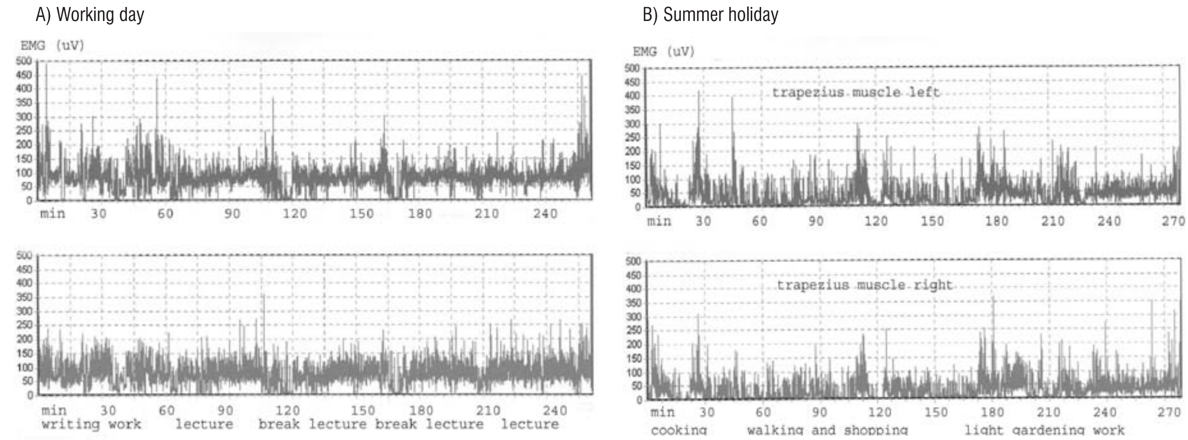

Fig. 2. Two different RMS-signal patterns (one second estimates) recorded from the trapezius muscle of the subject from the high school teacher group while performing different tasks on the working day (panel A) and in the holiday season (panel B). The subject was able to get muscle rest during the summer holidays throughout the recordings, whereas the same subject had difficulties in relaxing the muscle during the working day and showed quite long periods of static load.

in December and March. HR was significantly lower ($p < 0.05$) in the rescue workers in December, March and October. SBP and HR increased significantly with age ($p = 0.030$ and $p = 0.028$, respectively).

DISCUSSION

A psychophysiological stress in full-time teachers was high on three working days in December, March and November. Recovery from the stress was found during the summer holidays. The differences between the groups were not calculated in July because the measurement conditions differed in full-time teachers from those in other groups. In the teachers, measurements were performed during their holiday season (baseline) while in the other groups on their first working day after holidays. The teachers had longer summer holidays (10 weeks) than the subjects of

Table 5. Blood pressure and heart rate of full-time employed teachers in different months of one year compared to the values obtained in part-time retired teachers, gardeners and rescue workers

Gardiovascular response	Month	Subjects			
		Full-time employed teachers (n = 17)	Part-time retired teachers (n = 9)	Gardeners (n = 12)	Rescue workers (n = 13)
SPB (mmHg)	12	131 (14)/132(13)	143 (15)/156 (17)	32 (26)/137 (19)	142 (13)/148 (15)$^{\#\#}$
	3	130 (12)/131 (16) * **	143 (15)/152 (22)	131 (20)/134 (18)	137 (11)/146 (15)$^{\#\#}$ *
	7	122 (14)/122 (15)	146 (13)/142 (15)	128 (20)/129 (19)	136 (13)/136 (12)
	10	128 (14)/131 (18) *	142 (10)/145 (16)	127 (13)/132 (14)	142 (12)/145 (14) *
DPB (mmHg)	12	80 (8)/81 (8)	91 (7)/94 (5)	84 (11)/83 (9)	90 (9)/93 (7)$^{\#}$
	3	82 (9)/82 (9) * *	88 (6)/91 (9)	78 (8)/83 (9)	88 (9)/91 (8)$^{\#}$
	7	76 (8)/74 (8)	89 (9)/87 (5)	84 (11)/80 (9)	88 (9)/89 (10)
	10	80 (11)/81 (9) *	88 (4)/90 (5)	83 (8)/85 (7)	91 (10)/93 (11)
HR (bpm)	12	71 (10)/65 (7)$^{\#\#}$	76 (8)/67 (6)$^{\#\#}$	77 (13)/75 (11)76	72 (13)/65 (14)$^{\#}$
	3	68 (11)/63 (10)$^{\#}$	76 (8)/67 (10)$^{\#\#}$	(9)/75 (11)	72 (13)/63 (14)$^{\#}$
	7	68 (11)/67 (9)	76 (8)/69 (6)$^{\#\#}$	76 (9)/76 (11)	74 (9)/71 (9)
	10	71 (8)/67 (9)	79 (9)/66 (9)$^{\#\#}$	76 (11)/73 (11)	66 (10)/61 (9)$^{\#}$ *

Means (SD) for diastolic (DBP) and systolic blood pressure (SBP) and heart rate (HR) in the morning (7:00–10:00) and in the afternoon (14:00–16:30).
* $p < 0.05$, ** $p < 0.01$, Bonferroni post-hoc test.
$^{\#}$ $p < 0.05$, $^{\#\#}$ $p < 0.002$ morning vs. afternoon, t-test.

other groups (2–4 weeks). This may be the main reason that the differences between key periods varied less clearly in part-time teachers, gardeners and rescue workers than in the full-time teachers.

Work associated with great emotional stress produce a considerable increase in the urinary levels of catecholamines [8]. The epinephrine and norepinephrine values were at the normal reference level during the all four periods in full-time teachers. There was a significant decrease in the epinephrine levels during the summer holidays. This means that teachers experienced an increased sympathetic tone during the working days. According to the coping theory, individuals with elevated sympathoadrenal medullary activation represent the fight/flight type of active coping [17,33]. In the study of hospital cleaners carried out by Toivanen et al. [33] this stress reaction was greater than in present study of teachers. Their investigation was carried out during economically hard time in Finland, and the threat of unemployment was the most stressful factor in hospital cleaners. Whereas in teachers participating in the present study the most stressful factor seemed to be the work itself.

High rates of sick absence among gardeners was probably due to the musculoskeletal disorders induced by physically demanding work tasks. In teachers, somatic symptoms were quite rare, although they reported high perceived stress while working. In rescue workers, SBP and DBP were elevated, and the morning values increased in the afternoon. According to "reactivity hypothesis" [34], individuals who show increased cardiovascular reactivity during stress are at increased risk of developing cardiovascular diseases [35].

The EMG reliability can be considered sufficient as many of the factors influencing the results can be controlled. The placement of electrodes was done carefully by palpating the muscles and following the recommendations of Zipp [29]. Due to the self-preservation instinct and other protective mechanisms, the measurement of MVC always remains somewhat inaccurate [36,37]. For a more accurate normalization, a method in which muscle activity is measured from the submaximal muscle contractions has been proposed [38,39]. The APDF method can be used for describing occupational loads, although, with one drawback that the repeatability of the load is not reflected in the standard parameters. Another problem is that these three parameters are not statistically independent [30].

EMG recordings showed static muscle tension in full-time teachers when teaching continued for long periods, whereas in rescue workers they showed more dynamic patterns. According to the Cinderella hypothesis [20] it is crucial to have complete rest periods in order to prevent the development of chronic muscle pain. When evaluating the possibility to relax the trapezius muscle, shoulder stabilization, movements of the arm requirements and psychological stress should be taken into consideration [23,24].

The gender and age had no significant effects on "self-ratings". However, aging and gender are factors which may have influenced the physiological variables. In industrialized societies, age has the greatest influence on the BP level [40]. Adolescent boys start to display a higher average BP level than girls, and the difference in BP due to gender is most evident in young and middle-aged adults [40]. In the present study, gender had no significant effects on BP, but age had significant influence on SBP. Men generally display higher sympathetic-adrenal reactivity than women [41], which was also observed in this study. Laursen et al. [42] have found higher levels of EMG in the elderly (mean age, 63 years) compared to the young (mean age, 25 years) subjects during computer mouse tasks. However, these differences were smaller for the shoulder and neck muscles than for forearm extensor muscles.

CONCLUSIONS

1. Recovery from psychophysiological stress was found during the summer holidays in full-time teachers. Teachers' long holidays may support their work ability and health. In the working months, psychophysiolocigal stress should be decreased with stress coping programs.

2. Teaching is a more psychophysiolocigally stressing work than that of gardeners and rescue workers. Part-time retirement decreases psychophysiological stress in aging teachers and helps them to maintain their work ability until full retirement. More research is needed to clarify

effects of part-time retirement on work ability in teachers. Teachers' retirement age has been predicted to increase, which makes these studies urgent.

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