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Deep tissue hyperalgesia after computer work

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ABSTRACT

Background and purpose: A growing number of people are using computers. Shoulder and neck pain occur commonly during computer work. Peripheral and central sensitization may play a major role in establishing and maintaining several chronic pain conditions. We have previously reported that a 90 min simulated computer office-work induced substantial pain in the shoulders and neck. We hypothesized that the development of pain during the computer work may be related to sensitization. The aim of the present study was to examine if the 90 min computer work induced deep tissue muscle hyperalgesia manifested as altered pressure pain thresholds (PPTs).
Methods: Twenty-two subjects with chronic shoulder and neck pain (pain group) and 26 healthy and pain free subjects (reference group) performed a standardized computer office-work task with use of a computer-mouse and with time pressure and high precision demands continuously for 90 min. The pressure pain threshold was measured with a pressure algometer in shoulder and forearm muscles (bilaterally in upper trapezius and extensor carpi radialis), and at sternum, before and 15 min and 30 min after the computer work task.
Results: The PPTs before starting the computer work were not different between the groups at any of the five locations. In both groups, the PPTs in the active and inactive side of the upper trapezius as well as in the extensor carpi radialis of the forearm operating the computer mouse were significantly reduced after the 90 min computer work compared with the pre-work levels. In the pain group, also the PPT in the inactive resting forearm was significantly reduced. The changes seen in PPTs from pre- to post-work were not significantly different between the groups, except for the inactive resting forearm where the groups exhibited different time course.
Conclusion: A decrease in pressure pain thresholds of involved muscles suggests that computer office-work can induce deep tissue hyperalgesia within 90 min. The development of pain during the computer work indicates peripheral sensitization as the predominant mechanism. Decreased pressure pain thresholds also in sites distant from pain areas may indicate a contribution from central sensitization in the subjects with chronic shoulder and neck pain.
Implications: The lasting pain after work and the reduced PPTs both in involved and distant musculature may indicate need for frequent pauses during computer work, especially when performed with time pressure and high precision demands, in order to avoid pain to increase and sustain after work, and thus to prevent the possibility of pain to become chronic.

1. Introduction

A growing number of people are using computers. In 2007 about 30% of all employees in the European Union reported using computers all or most of the time for their work compared to 14% in 1991 [1]. Computer use may increase the risk of developing musculoskeletal symptoms in the upper extremities [2,3]. Shoulder and neck pain occur commonly, with prevalence rates around 10% [4–6].

Perception of acute musculoskeletal pain occurs in response to activation of group III (aδ-fiber) and group IV (C-fiber) muscle nociceptors. The nociceptors are activated by noxious or potentially noxious stimuli, and have a high mechanical stimulation threshold [7]. The muscle nociceptors are thus not excited by physiological movements. Musculoskeletal pain disorders are often associated with muscular hyperalgesia [8]. Deep tissue hyperalgesia may be

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explained by sensitization of muscle nociceptors and manifested as a decrease in the mechanical excitation threshold, often measured as a decreased pressure pain threshold (PPT) [9]. Among occupational office and industrial workers with shoulder and neck complaints, lower pressure pain thresholds in the shoulder and neck region compared to asymptomatic subjects is a common finding [10–15]. Studies targeting pressure pain sensitivity during and after muscle work show however inconsistent results. During light assembly work, both increased PPTs [16] and unchanged PPTs [17] of the working muscles in healthy subjects have been reported. During submaximal isometric upper or lower body exercise, increased, decreased or unchanged PPTs in corresponding musculature of healthy subjects, as well as in pain afflicted subjects, have been reported [18–26].

Continuing input from nociceptors may drive dorsal horn neurons into a state of sensitization [27]. Central sensitization is proposed to be one step in the transition from acute to chronic muscle pain [28]. Lowered pressure pain thresholds in sites distant from pain areas suggest a generalized sensitivity to pressure stimuli [29], and have been reported in subjects with shoulder and neck pain exposed to low-load repetitive work for months or years [11,15,30].

Peripheral and central sensitization may play a major role in establishing and maintaining several chronic pain conditions [27]. Recently, we have reported that computer office-work performed continuously for 90 min, with time pressure and high precision demands, induced substantial pain in the shoulders and neck as well as in the forearm operating the computer mouse both in subjects with chronic pain and in healthy references [31,32]. The aim of the present study was to examine if the 90 min computer work induced deep tissue muscle hyperalgesia manifested as altered pressure pain thresholds. We hypothesized that the development of pain during the 90 min computer work could be related to sensitization.

2. Material and methods

2.1. Subjects

A pain group consisting of 14 women and 10 men with chronic shoulder and neck pain and a reference group of 16 women and 12 men, all healthy and pain-free, were recruited through advertisements in local papers and the Internet.

Inclusion criteria for the pain group were: self reported pain in the shoulders or neck for at least 2–3 days per week during the previous 4 weeks and tender points in the upper trapezius muscles, age between 18 and 45 years, and working more than 80% full time and working with a computer more than 20% of the working time. The subjects had to be familiar with the Norwegian language to perform the text-editing task. Exclusion criteria were: fibromyalgia; cervicobrachialgia; rotator tendinosis or other shoulder disorders; inflammatory, metabolic or cardiac diseases; regular medication of importance for circulation; pregnancy; alcohol or medicament abuse; or dyslexia. The reference group was recruited with the same inclusion- and exclusion criteria as for the pain group, except that subjects with current musculoskeletal pain were excluded.

Two women in each group were excluded due to reporting pain as a consequence of the laser Doppler probes insertion in the trapezius muscle (see Refs. [31,32]). The mean age for those in the pain group was 39 ± (1SD) 6 years vs. 33 ± 6 years for those in the reference group, $p < 0.001$, and the body mass index respectively 23.2 ± 2.8 kg/m^2 vs. 23.6 ± 3.2 kg/m^2, $p = 0.62$. All except two were right handed. For further characteristics of the subjects, see Ref. [32].

All participants received written information and signed an informed consent. The Norwegian Regional Committee for Medical Research Ethics and the Norwegian Social Science Data Services approved the study.

2.2. Experimental protocol

All subjects reported to the laboratory twice; a pretest session and an experimental session. On average 5.5 (range 1–12) days separated the two sessions for subjects in the pain group vs. 4.2 (1–15) days for those in the reference group ($p = 0.12$).

At the pretest all subjects were examined by a specialist of physical medicine and rehabilitation. The examiner was aware of the subject's pain status, thus not blinded. The examination included range of motion of the cervical spine and shoulders, tests for nerve compression in the neck and upper extremities, and tests for subacromial problems. A neurological examination of muscle force, reflexes (biceps, triceps and brachioradialis tendon reflexes), and sensory function was performed on the upper extremities to identify any exclusion criteria. In addition, tender points in the neck and shoulder muscles, defined as localized pain occurring on a thumb pressure below 4 kg, and the typical areas of tenderness in fibromyalgia, were examined. None of the subjects fulfilled the ACR criteria for fibromyalgia [33], but all subjects in the pain group had tender points in the upper trapezius muscles (i.e. perceived pain on testing). The pretest further included familiarization with the measurements and procedures, and test trials of pressure pain thresholds before and after a 15 min computer work task training. During the computer training session the subject was encouraged to work as fast and accurately as possible without any pauses. The performance of this training session served to set the subject's standard for time pressure (see below), although the subjects were not aware of this.

At the experimental day the subjects reported to the laboratory in the morning. Pre-work PPTs were determined approximately 90 min before starting the computer work task, and before mounting the measurement equipments (the present study is part of a larger study, for more details see Refs. [31,32]. Post-work PPTs were performed 15 min and 30 min into the recovery period following the 90 min computer work task.

2.2.1. Computer work task

The computer office-work task consisted of using a computer mouse to correct typographical errors in a standardized text presented in a word processor (Microsoft Word 2000, Microsoft Corp., Seattle, WA, USA) as fast and as accurately as possible continuously for 90 min. Each error required at least two clicks with the left mouse button; first, the letter to be removed was marked and then a delete button in the word processor was activated. The task was designed to pose a high demand for precision in that all errors to be corrected required marking the letters f, i, j, l, and t in the letter type Arial in 11-point font. Each page comprised about 200 words with 20 spelling errors. The words with spelling errors were underlined in red, making them easy to locate to reduce the cognitive workload of the task. When a correct adjustment was made, the underlining disappeared. Pauses were not allowed, and the reporting of pain on the VAS was incorporated into the task using the same hand operations. The text was presented on a 17-inch LCD monitor (CTX model S721A, 1280 × 1024 pixels, Chuntex Electronics Co., Ltd, Taipei, Taiwan). A standard mouse (Logitech Inc., Fremont, CA, USA) with medium pointing speed was used, and this was operated by the subject's dominant hand.

During the 15-min work task training (at the pretest) the time spent to complete each page was recorded. The best (i.e. the shortest) time used to complete one page correctly was used to calculate the number of pages to complete for a period of 15 min, and ser-

Table 1
Pressure pain thresholds. Pressure pain thresholds (PPTs, kPa) before (pre-work) performing computer work in subjects with chronic shoulder and neck pain (Pain group; $n = 22$) and healthy reference subjects (Reference group; $n = 26$).

PPT measure site	Group	Mean	Standard deviation
Upper trapezius, active side	Pain group	343	170
	Reference group	350	154
Upper trapezius, inactive side	Pain group	365	182
	Reference group	361	145
Extensor carpi radialis, active side	Pain group	275	138
	Reference group	286	110
Extensor carpi radialis, inactive side	Pain group	258	125
	Reference group	245	93
Sternum	Pain group	311	133
	Reference group	340	103

Statistically significant main effects of measure site (ANOVA; $F = 5.45$, $p < 0.001$. Bonferroni's post hoc test revealed significant difference between the active trapezius and the inactive extensor carpi radialis, $p = 0.011$, and between the inactive trapezius and the active and inactive extensor carpi radialis, $p < 0.05$) and age (ANOVA; $F = 5.05$, $p = 0.026$).

ved as the individual performance target at the experimental day. The calculated target was on average 10 ± 2 pages per 15 min for the pain group vs. 11 ± 2 pages for the reference group ($p = 0.08$), corresponding to a mean working pace of 90 ± 19 s and 82 ± 15 s per page, respectively. Attaining the performance target elicited a monetary reward, NOK 25 (about US $5) every 15 min, giving a total obtainable reward of NOK 150. If any errors remained after a 15 min period, no reward was obtained in that period. Before starting the work task, each subject was told how many pages he or she had to complete during each 15 min period to attain the goal, and thus the reward. During the work task the subject received no information about the performance from the investigator but was told to keep pace by him/her-self.

2.3. Measurements

Pressure pain threshold, i.e. the pressure (kilopascals; kPa) when the sensation changed to a sensation of pain [34], was measured with an algometer (Somedic, Sollentuna, Sweden) with a tip size of 1 cm^2 covered with rubber. Pressure algometry provides a reliable and valid measure of PPT [35,36], reflecting pain sensitivity of deeper tissues [37]. The subjects were comfortable seated in a chair with the arms resting at a table, and the PPT recording sites were located and marked on the skin to ensure the same points to be used at all measurements. The pressure was applied perpendicular to the skin at a standardized rate of 50 kPa/s [30,37] in a fixed order; right and left medial upper trapezius, right and left muscle belly of extensor carpi radialis, and at sternum. The sequence was repeated three times and the mean value for each point was calculated and served as the PPT. The subjects reported the PPT by pressing a signal button attached to the algometer. All measurements were done by the same investigator. The subjects were explicitly instructed to respond to the threshold and not the tolerance.

2.4. Statistics

Statistical analyses were performed using the Statistical Package for the Social Sciences (release 18.0, SPSS Inc., Chicago, IL, USA). Mean ± 1standard deviation (SD) are reported, if not otherwise stated. For correlation analyses Spearman's rho was used. A two-tailed significance level of 5% was adopted.

The pre-work pressure pain thresholds were analysed using a 2-way ANOVA, with pressure pain threshold as dependent variable with measure site (active/inactive side of both upper trapezius and extensor carpi radialis, and sternum) and group (pain group/reference group) as fixed within factors. Post hoc tests were made using Bonferroni adjustment. To test for between-group effects, an interaction term (measure site*group) was added to the model. Due to the significantly younger age in the reference group than in the pain group, age was included as a covariate.

To fit the best model for the time course, i.e. modeling the mean response of the PPT at each of the five locations (i.e. at the active and inactive side of the upper trapezius, the active and inactive side of the extensor carpi radialis and at the sternum), linear mixed model analysis for repeated measurements was used [38]. Separate analysis was performed for each of the measure sites, where the time was treated as a categorical variable in which the measures taken after the work task (post-work) were compared with the baseline (pre-task) measure. Normality of the data was checked with residual plots, and due to non-normality, the PPT data of the extensor carpi radialis in the pain group were logarithmically (log) transformed prior to the time course analysis.

Differences in the time course of the PPT between the groups and between men and women in each group were tested by separate analyses for each measure site with use of the mixed model analysis, as described above. Age was included as a covariate in the analyses of group differences.

Longitudinal data show that the variances are seldom constant over time [38]. With repeated-measures data the correlation between time-points decreases as the time increases [39]. Thus, the models were fitted either with an unstructured or a heterogeneous first-order autoregressive covariance structure based on Akaike's information criterion for goodness of fit [38].

3. Results

3.1. Pre-work pressure pain thresholds

The pre-work PPTs were not different between the groups at any of the five locations (Table 1). In the reference group, lower pre-work PPT at sternum was found in the women than in men (307 ± 72 kPa vs. 385 ± 116 kPa, $p = 0.034$).

3.2. Changes in pressure pain thresholds

The pressure pain thresholds in the active and inactive side of the upper trapezius and in the extensor carpi radialis of the active forearm were significantly reduced at post-work compared with the pre-work levels in both the pain and reference groups, as well as in the extensor carpi radialis of the inactive resting forearm in the pain group (Table 2).

During recovery, from 15 min post-work to 30 min post-work, a statistically significant increase in PPT was found for the inactive trapezius in the pain group (95% CI 1–39 kPa) and at sternum in the reference group (95% CI 10–46 kPa).

Table 2
Changes in pressure pain threshold. Estimated regression coefficients (β) and 95% confidence intervals (CI) based on the fitted linear models[a] of pressure pain threshold (PPT, kPa) changes from before starting the computer work to 15 min and 30 min, respectively, after performing 90 min computer work, in shoulder muscles (active and inactive side of the upper trapezius), forearm muscles (active and inactive side of extensor carpi radialis), and at sternum in subjects of the pain ($n = 22$) and reference groups ($n = 26$).

	Estimate of the β	95% CI	T	p-Value
Active upper trapezius				
Pain group				
(β1) Intercept[b]	343	272–413	10.1	<0.001
(β2) Change from pre-work to 15 min post-work	−32	−61 to −3	−2.2	0.032
(β3) Change from pre-work to 30 min post-work	−23	−44 to −2	−2.3	0.030
Reference group				
(β1) Intercept	358	293–423	11.4	<0.001
(β2) Change from pre-work to 15 min post-work	−30	−59 to −10	−3.2	0.004
(β3) Change from pre-work to 30 min post-work	−32	−54 to −10	−3.1	0.005
Inactive upper trapezius				
Pain group				
(β1) Intercept	368	296–440	10.5	<0.001
(β2) Change from pre-work to 15 min post-work	−39	−78 to −2	−2.1	0.039
(β3) Change from pre-work to 30 min post-work	−18	−45 to 10	−1.3	0.19
Reference group				
(β1) Intercept	369	307–430	12.4	<0.001
(β2) Change from pre-work to 15 min post-work	−17	−36 to 3	−1.8	0.086
(β3) Change from pre-work to 30 min post-work	−27	−53 −0.5	−2.1	0.046
Active extensor carpi radialis				
Pain group[c]				
(β1) Intercept	245	202–297	58.3	<0.001
(β2) Change from pre-work to 15 min post-work	−18	−31 to 3	−1.8	0.078
(β3) Change from pre-work to 30 min post-work	−32	− 41 to −15	−3.2	0.002
Reference group				
(β1) Intercept	296	248–344	12.7	<0.001
(β2) Change from pre-work to 15 min post-work	−3	−20 to 14	−0.4	0.73
(β3) Change from pre-work to 30 min post-work	−15	−29 to −1	−2.2	0.041
Inactive extensor carpi radialis				
Pain group[c]				
(β1) Intercept	230	189–279	58.0	<0.001
(β2) Change from pre-work to 15 min post-work	−16	−26 to 1	−1.9	0.065
(β3) Change from pre-work to 30 min post-work	−18	−27 to −2	−2.2	0.035
Reference group				
(β1) Intercept	250	212–289	13.4	<0.001
(β2) Change from pre-work to 15 min post-work	1	−12 to 14	0.2	0.84
(β3) Change from pre-work to 30 min post-work	7	−10 to 25	0.8	0.41
Sternum				
Pain group				
(β1) Intercept	313	262–363	12.8	<0.001
(β2) Change from pre-work to 15 min post-work	−19	−41 to 3	−1.8	0.087
(β3) Change from pre-work to 30 min post-work	−8	−23 to 8	−1.0	0.33
Reference group				
(β1) Intercept	337	298–376	17.6	<0.001
(β2) Change from pre-work to 15 min post-work	−10	−25 to 5	−1.4	0.17
(β3) Change from pre-work to 30 min post-work	16	−12 to 47	1.2	0.26

[a] Linear mixed models for repeated measurements fitted with unstructured or first-order autoregressive covariance structure, analysed separately for each group and measure site. Including age as a cofactor did not influence the results.
[b] The intercepts (β1) represent estimate of pre-work PPTs.
[c] Due to non-normality, the PPT data were logarithmically transformed prior to analysis. The presented data are back-transformed to the original scale.

3.3. Group differences in pressure pain threshold changes

The changes in PPTs from pre-work to post-work (Fig. 1a and b) were significantly different between the groups only for the inactive extensor carpi radialis at 30 min post-work ($p = 0.050$).

3.4. Pain intensity

The pain intensity results have been published previously [31,32]. In short, the pre-work ratings of current pain intensity (reported on a 100 mm visual analogue scale; VAS) prior to starting the computer task showed higher pain intensity in the pain group than in the reference group (Table 3). The increase in pain intensities during the 90 min work task was highly significant ($p < 0.001$) in both groups, but it was not significantly different between the groups ($p > 0.15$). The pain intensity did not return to baseline values in either group during the recovery period ([31,32]; Table 3).

3.5. Correlations between pressure pain threshold and pain intensity

The PPTs exhibited negative correlations with the pain intensity ratings in both groups (Table 4).

Table 3
Pain intensity. Pain intensity (mean ± 1standard deviation; SD) rated at a visual analogue scale (from 0 mm; no pain to 100 mm; intolerable pain) before (pre-work) performing a 90 min computer work, at the work task end and at 15 min and 30 min post-work, in subjects with chronic shoulder and neck pain (Pain group; $n = 22$) and healthy reference subjects (Reference group; $n = 26$).

	Group	Pre-work	Work task end	Post-work	
				15 min	30 min
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Shoulder/neck, active side	Pain group	10.5 (8)	57 (25)	48 (27)	42 (28)
	Reference group	3 (2)	43 (28)	29 (24)	19 (20)
Shoulder/neck, inactive side	Pain group	9 (7)	46 (26)	41 (25)	33 (25)
	Reference group	3 (3)	33 (27)	21 (22)	15 (18)
Forearm/wrist, active side	Pain group	5 (5)	46 (24)	33 (23)	30 (25)
	Reference group	3 (2)	32 (27)	15 (16)	9 (10)
Forearm/wrist, inactive side	Pain group	5 (5)	28 (24)	21 (18)	15 (14)
	Reference group	3 (3)	19 (16)	10 (10)	5 (5)

The time course analyses of the pain intensity data are presented elsewhere [31,32].

4. Discussion

The present study demonstrated decreased pressure pain thresholds in involved muscles after performing continuously computer office-work for 90 min both in subjects with chronic shoulder and neck pain and healthy reference subjects. In addition, pressure pain thresholds in the chronic pain subjects were decreased also in sites distant from the involved muscles.

4.1. Pressure pain sensitivity after performing computer work

Performing the present computer office-work induced substantial pain in the shoulders and neck and in the forearm operating the computer mouse that lasted after the work (Table 3, and Refs. [31,32]). After performing the computer work, that was imposed with time pressure and high precision demands for 90 min without pauses, the PPTs in the shoulders and in the active side of the forearm were significantly reduced in subjects of both the pain and reference groups (Fig. 1, Table 2). This could indicate that the task produced muscular hyperalgesia to pressure stimuli.

Both peripheral and central mechanisms may be involved in muscular hyperalgesia [9]. The sensation of pressure and pain is the result of stimulation of nociceptive nerve endings in superficial and deeper tissues. Sensitization of muscle nociceptors may lead to a decrease of the mechanical threshold into the innocuous range, and thus represents a peripheral mechanism which may explain aspects of muscle hyperalgesia [28]. Experimental muscle pain and muscular hyperalgesia to mechanical stimuli have been reported after intramuscular injection of the combination of serotonin and bradykinin [40], but have, to our knowledge, not been reported previously after a session of experimental low-load computer office work. Muscle nociceptors may be activated by inflammatory substances such as bradykinin, serotonin and prostaglandins [28]. The present computer work task induced peripheral vasodilation in the trapezius muscles, similar in both groups, that was found to be associated with the pain intensity [31,32], a finding that may support the hypothesis that the blood vessel–nociceptor interac-

Table 4
Correlations between pain intensities and pressure pain thresholds. Correlation coefficients (Spearman's rho) between the pain intensity in the active and inactive side of the shoulder/neck and forearm/wrist, respectively, reported immediately after performing the 90 min computer work and at 15 min and 30 min post-work, and the pressure pain thresholds (PPT) measured at 15 min and 30 min post-work in the active and inactive upper trapezius and extensor carpi radialis muscles, respectively, in subjects with chronic shoulder and neck pain (Pain group; $n = 22$) and healthy reference subjects (Reference group; $n = 26$).

Pain intensity	PPT			
	15 min post-work		30 min post-work	
	Pain group	Ref group	Pain group	Ref group
Shoulder/neck	Upper trapezius			
Active side				
Work end (90 min)	−0.42*	−0.23	−0.30	−0.31
15 min post-work	−0.37	−0.26	−0.21	−0.13
30 min post-work			−0.27	−0.26
Inactive side				
Work end (90 min)	−0.38	−0.24	−0.27	−0.30
15 min post-work	−0.33	−0.12	−0.18	−0.25
30 min post-work			−0.23	−0.25
Forearm/wrist	Extensor carpi radialis			
Active side				
Work end (90 min)	−0.36	−0.40*	−0.38	−0.37
15 min post-work	−0.21	−0.36	−0.21	−0.46*
30 min post-work			−0.16	−0.31
Inactive side				
Work end (90 min)	−0.44*	−0.52**	−0.44*	−0.40*
15 min post-work	−0.43*	−0.28	−0.42*	−0.24
30 min post-work			−0.16	−0.27

* Statistically significant at a level of 0.05.
** Statistically significant at a level of 0.01.

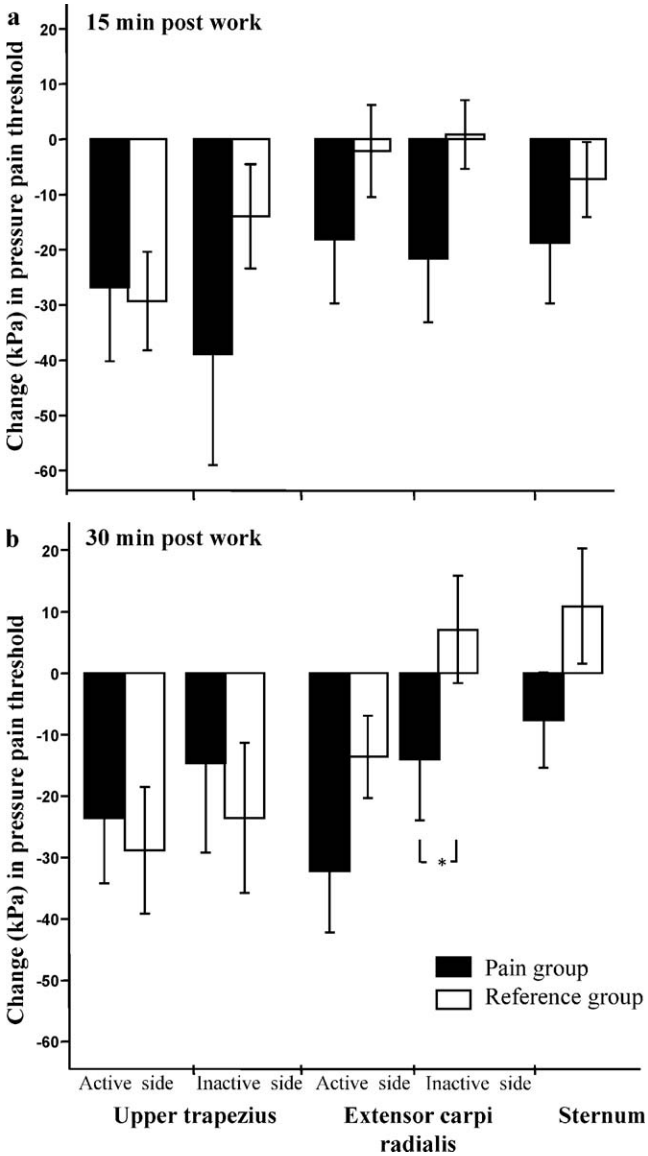

Fig. 1. Changes in pressure pain thresholds (PPTs) from pre-work to post-work. Mean changes (kPa) in PPTs from pre-work to (a) 15 min post-work and (b) 30 min post-work at the different measure sites in subjects of the pain ($n = 22$) and reference ($n = 26$) groups after performing computer work for 90 min. Negative bars indicate reduction in the PPT and the ticks represent ± 1standard error of the mean. Asterisk (*) indicates statistically significant difference between the groups ($p < 0.05$).

tion is important to the activation of muscle nociceptors (see Refs. [41,42]). In the skeletal muscles nociceptors are located at the wall of arterioles and in the surrounding connective tissue [7]. The muscle pain may arise from interaction between the vessel and nerve of the connective tissue of the muscle, where putative mechanisms are vasodilation, vascular production and release of algogenic factors, and inflammation [41,42]. Both the nerves that innervate the blood vessels and the vessels themselves may produce factors that contribute to nociception, like prostaglandins, bradykinin, nitric oxide, and serotonin. In patients with chronic work-related trapezius myalgia increased levels of muscle serotonin, glutamate, [43], and bradykinin [44] have been reported at rest and during exercise compared to healthy controls.

The present study protocol exposed the subjects to several PPT measurements at the same site that possibly could result in local tissue responses brought on by the repeated pressure stimulation. Thus, the reduced pressure pain thresholds found after work could possibly also be due to a time effect of the repeated pressure stimulation, and not due to the work task performed. However, if the repeated pressure stimulation was to be the main causation of the hyperalgesia, it would be reasonable to assume that the 30 min post-work values should be further reduced from those at the 15 min post-work. Analyzing the change in PPT from 15 min post-work to 30 min post-work revealed no statistically significant change except for the inactive trapezius in the pain group and at sternum in the reference group, where the PPTs increased. In addition, the PPTs were negatively correlated with the perceived pain intensities (Table 4). Furthermore, test-retest reliability of PPT values has been found to be robust and highly consistent during repeated measurements [26,45]. In the study by Jones et al. [45] a lowering of PPTs with repeated measurements was however reported, but the decrease in PPT was mainly seen between measurement 1 and 2. Similarly, in the present study we found the pre-work PPTs to be significantly lower than that at the pretest (data not shown), thus indicating the importance of being familiarized with the measurements.

The reduced PPT's after the computer task in the present study contrasts with findings of studies investigating PPT during work. Nakata et al. [17] found no significant trapezius PPT change during experimental light assembly work for 2 h in 13 healthy females, but found PPT to be negatively correlated with perceived muscular discomfort (mean VAS ca 20 mm). Mathiassen and Winkel [16] measured trapezius PPT repeatedly during a working day in eight healthy females during light assembly work and found the PPT to be lowest in the beginning of the work and thereafter steadily increasing. Increased PPT has also been found after static submaximal exercise of the trapezius [24–26], infraspinatus and quadriceps femoris muscles [22], possibly due to activation of central nervous antinociceptive mechanisms [46]. Performing 50 dynamic eccentric contractions of the shoulder muscles at a force equal to 100% maximum voluntary contraction (MVC) caused, however, the PPTs in the trapezius to be decreased [47]. In the present study the muscle activity levels (reflected by electromyography; EMG) were low both bilaterally in the upper trapezius muscles (<5% of EMG during MVC) and in the active forearm muscles (<10% of EMG during MVC), and similar in both groups [31,32]. Different types of work, exercise, and intensities thus seem to elicit different responses in pressure pain thresholds.

In the inactive resting forearm of the chronic pain subjects, the pressure pain thresholds were decreased after the work task as well, and tended to be at sternum (Table 2). This was in contrast to the lack of significant PPT changes at these measure sites in the reference group (Table 2). Lowered pressure pain thresholds in sites distant from pain areas have been reported in subjects with shoulder and neck pain after employment in low-load repetitive work for several months [15] or years [11,30], and suggests a generalized sensitivity to pressure [29] that may involve central sensitization [9]. Generalized musculoskeletal pain is one of the most important clinical characteristics of the fibromyalgia syndrome (FM) [33]. However, FM subjects were not included in the present study. During the present computer work task there was a modest increase in the pain intensity (approximately 20 mm) in the resting forearm of the subjects of both groups. The participants had on their third finger on this side mounted a cuff for measurement of heart rate and blood pressure (see Refs. [31,32]), and the rated pain may reflect unpleasantness with this cuff. Furthermore, the present study protocol exposed the subjects to several PPT measurements at the same site that possibly could result in local tissue responses brought on by the repeated pressure stimulation, as discussed above. Both groups were however exposed to the same protocol. Thus, a more generalized hyperalgesia and a possible involvement of central mechanisms cannot be excluded in the chronic pain subjects.

The substantial increase in pain during the present computer work, the lasting pain after the work and the reduced PPTs, may indicate need for frequent pauses during computer work in order to avoid pain to increase and sustain after work, and thus to prevent the possibility of pain to become chronic. This might especially be important when performed with time pressure and high precision demands. Further studies are needed to elucidate this.

4.2. Pain threshold levels

The pre-task PPTs (Table 1) appear to be in accordance with those reported in healthy and pain-free subjects of other studies [26,43]. Higher sensitivity to pressure pain in the shoulder and neck region is a more common finding in subjects with shoulder and neck complaints than in asymptomatic subjects [11,12,14,15,43]. The present results contrast with this in that we found similar PPT in all measurement sites in both the pain and reference groups. The subjects of the pain group reported the shoulder and neck pain complaints lasting from six months to more than ten years [32], hence they met customary criteria for chronicity. However, they were not severely pain afflicted since they were in fulltime work and not recruited from a patient population. In addition, the pain intensity change from pre-work to work task end was not significantly different from the reference group.

There were no significant differences between men and women in PPTs in the groups either before or after the office work task (except for at sternum in the reference group). This finding contradicts the majority of the literature reporting lower pressure pain thresholds in women (see Ref. [48]). Riley et al. [49] suggested that studies failing to identify sex differences in PPT have too few subjects included and thus lack of power. The present study was however not set up to investigate sex differences; hence a potential difference between men and women cannot be excluded.

5. Conclusion

A lasting decrease in pressure pain thresholds bilaterally in upper trapezius muscles suggests that computer office-work, with time pressure and unilateral hand precision demands, can induce deep tissue hyperalgesia within 90 min both in subjects with chronic shoulder and neck pain and healthy references. The development of pain during the computer work indicates peripheral sensitization of muscle nociceptors as the predominant mechanism. Decreased pressure pain thresholds also in sites distant from pain areas may indicate a contribution from central sensitization in pain development in the subjects with chronic shoulder and neck pain.

Conflict of interest

The authors declare that there are no financial or other relationships that might lead to a conflict of interest.

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