# Risks of Occupational Vibration Exposures

# VIBRISKS

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**Title:** Longitudinal epidemiological surveys in Sweden of workers exposed to hand-transmitted vibration


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# 1 Surveys in Sweden of workers exposed to hand-transmitted vibration

## 1.1 Establishing the Swedish HTV cohorts

The Swedish study group, surveyed by Partner 4 (UMUH), consists of students that had graduated from vocational high schools in 2001, 2002 and in 2003 in northern and western Sweden. The programs were construction, auto mechanics and restaurant (originally 3000 asked). A short screening self-administered questionnaire with questions comparable to the VIBRISK self-administered questionnaire (WP2-N8) but less detailed was used (Appendix Vibit questionnaire). A study base of 1868 young workers (1561 men and 307 women) that answered the screening questionnaire was the base for setting up the Swedish VIBRISKS HTV cohorts. The cohort of 1868 young workers (1561 men and 307 women) workers with different levels of HTV exposure is in the following termed Vibit-cohort.

A total 1029 workers from the Vibit-cohort questionnaire were given a baseline questionnaire which was a Swedish translation of the VIBRISKS self-administered questionnaire (SAQ) developed within WP1 (i.e VIBRISKS Working documents WP4-N12 and WP4-N8, respectively). The 1029 workers were those from the Vibit-cohort that had answered yes to a question whether they volunteered to participate in further research studies. This questionnaire was answered by 804 workers (response rate: 78%). Of these some was returned due to untraceable individual addresses and some declared that they did not want to participate in the study. Thus, 794 young workers were included in the final Swedish SAQ HTV cohort.

From the Vibit-cohort 208 young workers were according to the work plan enlisted in a clinical assessment cohort, in the following termed Swedish Clinical HTV cohort. These young workers had different level of HTV exposures. Effect measurements included physical examination and testing (eg. finger systolic blood pressure (FSP), thermal perception thresholds, vibrotactile perception thresholds, monofilament, Purdue dexterity test, Jamar test, pinch strength). Physical examination were done in line with a Swedish version of the clinically administrated questionnaire developed in WP1, i.e. VIBRISK Working Document WP1-N13 and WP4-N7, respectively). Assessment of exposure was based on individual interviews. The raw data collection was completed during 2005 and data evaluation and statistical analysis (with SPSS and SAS) is ongoing. The follow-up of these 208 workers was done September to December 2006.

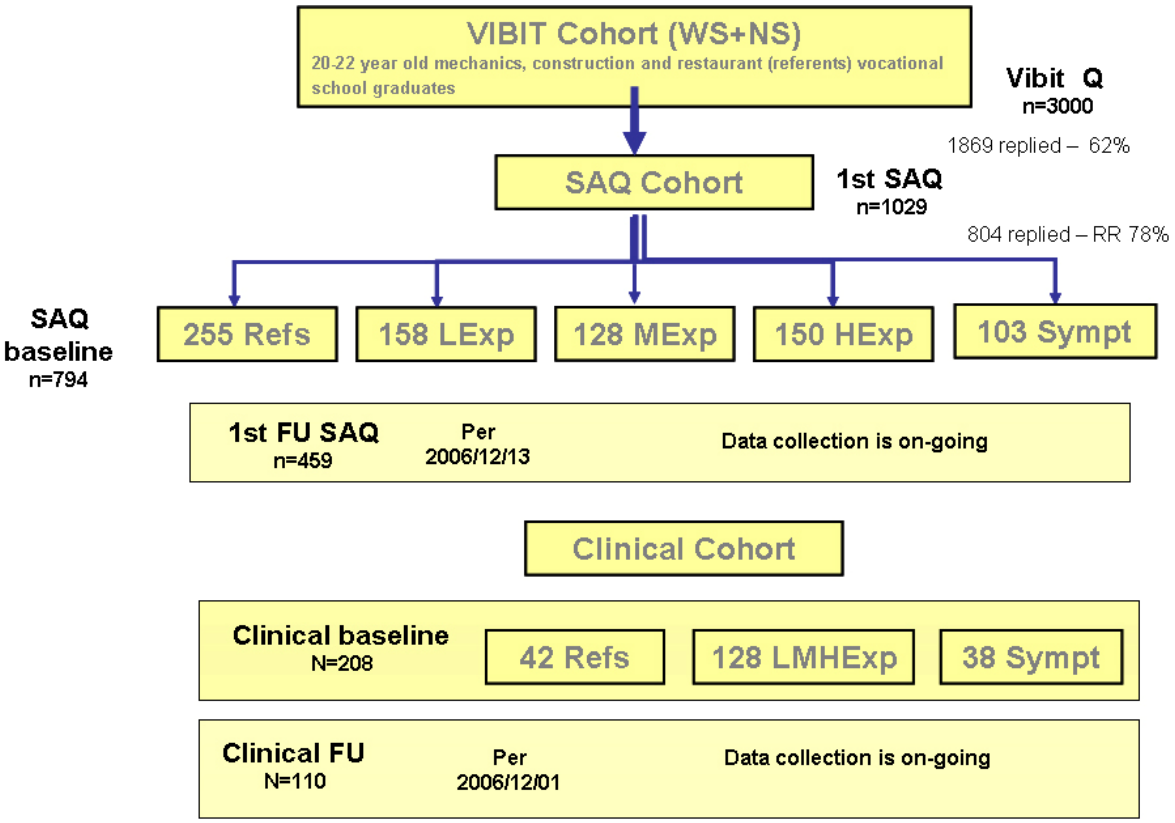


Figure 1. Swedish cohorts. WS= western Sweden, NS= Northern Sweden. Q=questionnaire. LExp= low hand transmitted vibration exposed, MExp= median hand transmitted vibration exposed, HExp= high hand transmitted vibration exposed. Sympt= workers with tingling or color changes of fingers in vibit questionnaire. FU= follow up.

# 2 Results from the VIBIT cohort

There were 1868 (1561 men and 307 women) persons that answered the screening questionnaire. The median age was the same in exposed and not exposed (controls) men and women (Table 1). The range of daily exposure among the HTV exposed had a large range (Table 2). Thus it was possible to enlist workers with different levels in the 208 workers sub cohort for the effect examination and laboratory tests.

Table 1. Characteristics of the study population "young workers"(VIBIT cohort Sweden cross-sectional survey). Data are given as medians and (range= lowest and highest value) or numbers (%).

| | Controls men | HTV exposed men | Controls women | HTV exposed women |
|---|---|---|---|---|
| Number of persons | 498 | 1060 | 204 | 102 |
| Age (yrs) | 21 (19-27) | 21 (19-27) | 21 (18-24) | 20 (18-26) |
| Height (cm) | 180 (165-196) | 182 (165-197) | 167 (150-184) | 167 (150-185) |
| Weight (kg) | 77 (55-118) | 78 (65-116) | 62 (44-102) | 62 (45-115) |
| BMI ($Kg/m^2$) | 23,6 (17,8-35,1) | 23,6 (18,2-35,1) | 22,3 (16,6-38,7) | 22,1 (17,2-39,1) |
| Smokers (n) | 74 (15%) | 151 (14%) | 51 (25%) | 33 (32%) |
| Total abstainers of alcohol (n) | 46 (9%) | 61 (6%) | 7 (3%) | 5 (6%) |
| Daily HTV exposure (min) | 0 | 45 (1-540) | 0 | 20 (1-480) |

The prevalences of white fingers in exposed and not exposed men and women were low and as expected in the age category in the different groups (Table 2). The prevalences of possible CTS (night tingling) in exposed and not exposed men and women were high in all the different groups (Table 2).

There were associations between HTV exposure and night tingling and wrist pain for men, neck, arm and low back pain for women (Table 3).

Table 2. Prevalence of upper limb disorders in the controls and the HTV exposed in the study population "young workers" (VIBIT cohort Sweden cross-sectional survey): numbers and (%).

| | Controls men | HTV exposed men | Controls women | HTV exposed women |
|---|---|---|---|---|
| Number of persons | 498 | 1060 | 204 | 102 |
| Tingling/numbness in hands/fingers (7d last year) | 41 (8%) | 90 (8%) | 22 (11%) | 19 (18%) |
| At night tingling/numbness in hands/fingers (possible CTS 30d) | 49 (10%) | 152 (14%) | 33 (16%) | 25 (24%) |
| Coldness in hands/fingers (30d) | 111 (22%) | 274 (26%) | 109 (53%) | 64 (62%) |
| Finger whiteness colour chart (30d) | 17 (3%) | 42 (4%) | 7 (3%) | 7 (7%) |
| Neck pain (7d last y) | 160 (32%) | 350 (33%) | 89 (44%) | 64 (62%) |
| Arm pain (7d last y) | 126 (25%) | 304 (29%) | 67 (33%) | 62 (60%) |
| Wrist pain (7d last y) | 71 (14%) | 246 (23%) | 62 (30%) | 42 (41%) |
| Low back pain (7d last y) | 174 (35%) | 381 (36%) | 93 (46%) | 60 (58%) |
| Stress (burn out) | 182 (37%) | 405 (38%) | 109 (53%) | 57 (56%) |

Table 3. Associations of upper limb disorders and HTV exposure in the study population "young workers" (VIBIT cohort Sweden cross-sectional survey). Prevalence ratios (PR) and 95% confidence intervals (95% CI) are reported, assuming the controls as the reference category (PR=1,0).

| | Prevalence ratio HTV exposed men | 95%CI | Prevalence ratio HTV exposed women | 95%CI |
|---|---|---|---|---|
| Tingling/numbness in hands/fingers (7d last y) | 1,03 | 0,70-1,52 | 1,71 | 0,97-3,01 |
| At night tingling/numbness in hands/fingers (possible CTS 30d) | 1,45 | 1,07-1,97 | 1,50 | 0,94-2,38 |
| Coldness in hands/fingers (30d) | 1,16 | 0,95-1,40 | 1,16 | 0,95-1,42 |
| Finger whiteness color chart(30d) | 1,16 | 0,67-2,01 | 1,98 | 0,71-5,50 |
| Neck pain (7d last y) | 1,02 | 0,88-1,20 | 1,42 | 1,15-1,77 |
| Arm pain (7d last y) | 1,13 | 0,95-1,35 | 1,54 | 1,17-2,02 |
| Wrist pain (7d last y) | 1,62 | 1,27-2,07 | 1,34 | 0,98-1,83 |
| Low back pain (7d last y) | 1,03 | 0,89-1,19 | 1,28 | 1,02-1,60 |
| Stress (burn out) | 1,04 | 0,91-1,20 | 1,04 | 0,74-1,24 |

# 3 Results from the baseline SAQ HTV cohort

## 3.1 Population summary

The population summary shown in Table 4 has been established on the basis of data obtained through the self-administered HTV questionnaire.

Table 4. Population summary

| **Population** | **SWEDISH SAQ HTV COHORT** | |
|---|---|---|
| Population Swedish Cohort<br>N= 852 (Age 19-26 yrs) | Not or very low exposed | Mechanics/construction workers |
| Number included: 793 | 315 | 478 |
| Median age 2005 (upper and lower quartiles) | 22 yrs (Q1=21; Q3=22) | 22 yrs (Q1=21; Q3=22) |
| Tool(s) | No tools | Grinders, drills etc |
| **Assessed exposure among exposed – Mean (SD)** | | |
| Dose 1: Total hours exposure | | 636 (2726) |
| Dose 2: a*t weighted total dose | | 1911 (10369) |
| Dose 3: a^2*t weighted total dose | | 8074 (4156) |
| Dose 4: a^4*t weighted total dose | | 190856 (920880) |
| Dose 8: A – max weighted any tool | | 2,62 (2,76) |
| Dose 10: Total exposure years | | 2,2 (2,9) |
| Dose 14: Current weighted A(8) | | 0,85 (1,41) |
| Dose 16: Leisure time exposure hours | | 23,5 (194) |
| Dose 17: Leisure a*t weighted total dose | | 81,6 (1003) |
| Dose 18: Work & Leisure sum hours | | 671 (2739) |
| Dose 19: Works & Leisure a*t weighted total | | 2038 (10457) |
| Dose 20: Work & Leisure total dose per year | | 1042 (2050) |
| **From questionnaire (symptoms)** | | |
| (n=number of questionnaire replies) | **Not/very low exposed** | **Exposed** |
| % who have ever experienced any colour changes in the fingers | 22,4 (299) | 31,8 (466) |
| % who have ever experienced tingling | 21,7 (304) | 35,9 (471) |
| % who have ever experienced numbness | 17,5 (303) | 30,3 (472) |
| % who have had or have neck pain | 42,8 (304) | 46,8 (472) |
| % who have had or have shoulder pain | 63,1 (141) | 62,4 (242) |
| % who have had or have elbow pain | 18,7 (139) | 27,3 (238) |
| % who have had or have wrist pain | 42,4 (139) | 40,2 (239) |

## 3.2 Prevalence of vascular, sensorineural, and musculoskeletal symptoms at the cross-sectional survey of the study population

Table 5. Baseline. **Prevalence of symptoms (in %).**

| | **Men** | | **Women** | |
|---|---|---|---|---|
| | **Referents** | **HTV exposed** | **Referents** | **HTV exposed** |
| *N* | *87* | *576* | *180* | *9* |
| Numbness in hands/fingers at night | 1 | 9 | 10 | 37 |
| No power in handgrip | 4 | 7 | 10 | 12 |
| Easy to drop objects | 3 | 4 | 10 | 25 |
| Pain in wrist | 8 | 17 | 27 | 38 |
| Pain in finger | 8 | 12 | 9 | 25 |
| Coldness in hands/fingers | 8 | 15 | 15 | 25 |
| Whiteness in one or more fingers when cold or damp | 4 | 13 | 13 | 25 |
| Hard to button | 0 | 3 | 1 | 12 |
| Fingers changing colour | 18 | 30 | 25 | 50 |
| Tingling/pricking in fingers | 18 | 32 | 31 | 50 |
| Neck pain (last 12 months) | 21 | 21 | 23 | 25 |
| Arm pain (last 12 months) | 43 | 29 | 29 | 33 |

# 4 Main results of Swedish Clinical HTV cohort

## 4.1 Thermal perception thresholds among young adults exposed to hand-transmitted vibration

### 4.1.1 Introduction

Quantitative sensory testing (QST) non-invasively assesses the function of the sensory pathways from receptors to the cortex [1]. The thermal testing modality for cold is peripherally mediated by small myelinated fibres (A-delta) and warm sensation by un-myelinated warm specific C-fibres. Conventional electro diagnostic methods are not able to reveal the function of these small diameter nerve fibres [2]. The clinical diagnosis of sensory unit dysfunction of small diameter nerve fibre (SDNF) neuropathy is thus a challenge because of minor clinical signs, both hyper- and hypo-perception symptoms, sometimes associated with pain and normal conventional nerve conduction findings [3]. Experimental studies, case series of patients, and cross-sectional studies of workers exposed to vibration supports evidence that neuro-sensory hand-arm vibration syndrome also encompasses neuropathy of the small-diameter nerve fibres [4].

### 4.1.2 Objectives

To assess the risk of disturbed thermal perception developing among young adults exposed to vibration and hand intensive manual work including wearing from wet-work and heat. The aim also encompasses the study of alternative confounding factors related to SDNF neuropathy.

### 4.1.3 Methods

The study population of this cross-sectional study of 208 male and female young adults came from vocational auto mechanic, construction and restaurant school programs. They were offered to participate based on enrollment lists from the last year in vocational school programs. A postal, self administrated, baseline questionnaire, a clinical examination with medical and exposure history and additional tests were included. Quantitative measurement of thermal perception thresholds were performed, on both hands, by a modified Marstock method. A thermo stimulator was applied to the skin on the volar surface of the two distal phalanges of the second and fifth digit. The measurement of warmth and cold perception thresholds were repeated 6-times. The perceptual threshold for warmth and cold and the difference limens (neutral zone) was thus reached. The starting point was a neutral 32°C temperature.

The study population included 24 females and 184 male young adults. Three persons were excluded due to insulin-dependent diabetes 2 persons due to gastrointestinal malabsorption disease. One person lacked exposure information leaving the final study population to 202 persons. The mean age for the women was 20.5 years (S.D. 0.9). The men were half a year older. Eleven of the women had no exposure to vibration at work or at free-time. The corresponding number for the men was nine. For the exposed group the total mean vibration exposure (free-time and work accumulated) was 4887mh/$s^2$ (s.d. 7375 mh/$s^2$) the corresponding values for women were 1802 (s.d. 2187 mh/$s^2$). Free-time exposure was approximately 1000 mh/$s^2$ for both men and women.

### 4.1.4 Results

The thermal sensitivity (lower threshold for warmth and higher for cold) was generally higher for women both exposed and unexposed to vibration. When comparing never exposed men or women with vibration exposed men or women a lower sensitivity was noted for the vibration exposed groups. The mean differences were significant for the difference limens for the 2$^{nd}$ and 5$^{th}$ fingers both on the left and right hand side. The contrast between exposed and unexposed tended to be larger for cold perception compared to warmth perception. The excluded subjects had less sensitive thresholds compared to the corresponding mean values of the male group. A weak ($r^2$ .02 and 03), significant relation was found between reduced thermal perceptual sensitivity and length. Analysis of individual outliers gave attention to the possible influence also from pain, sequelae after accidents and vascular function.

### 4.1.5 Discussion and conclusions

The results indicate thermal sensory impairment related to vibration exposure, gender, length, and disease (e.g. diabetes). These findings are in agreement with the results from other studies. Sensory impairment despite the young adults' short vibration exposure-time and mainly low exposure calls for strict methodology and careful interpretation of results before a small diameter nerve fiber neuropathy should be diagnosed as vibration induced in individual cases. Conventional clinical and electro diagnostic investigations of subjects with neurological sensory disturbances fall short in evaluating the status of the small calibre afferent systems. Leaving QST of thermal perception as one optional diagnostic tool [3, 5, 6] in addition to pain perception.

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## 4.2 Hand symptoms among young adults in relation to vibrotactile and monofilament tests

### 4.2.1 Introduction

Hand-held vibrating tools are commonly used in different occupations. The tools vary in size, weight, acceleration amplitude and frequency. Vibration exposure may cause a variety of symptoms, depicted as the hand-arm vibration syndrome (HAVS). The symptoms may be of vascular, neural, and muscular origin and may appear as digital vasospasm (vibration white fingers; VWF), sensorineural disturbances [1] and/or as muscular weakness and fatigue. The interindividual susceptibility may vary between different subjects and the dose-response relationships are not fully clarified.

### 4.2.2 Objectives

To study early neurophysiological effects by monofilament testing and determination of vibrotactile thresholds, in young workers with hand-held vibration exposure.

### 4.2.3 Methods

The study consisted of 144 male and female workers with exposure to hand-held vibrating tools. Many of them had been working in machine shops. They were compared with 61 non-vibration exposed subjects, mainly restaurant employees of the same age-group. The study population started their work during the period 1998-2005. All participants passed a structured interview and answered several questionnaires with questions about e.g. working and medical history, smoking and alcohol consumption, vibration exposure and vibration related symptoms such as white fingers and sensorineural disturbances. A physical examination was performed followed by several tests, e.g. the determination of vibrotactile perception thresholds, temperature thresholds, Semmes Weinstein Monofilament, Purdue dexterity test, Jamar test and Pinch strength. Measurements of vibrotactile thresholds were performed for two frequencies (31.5 and 125 Hz). The Touch Test Sensory Evaluators (Semmes-Weinstein Monofilament) provide a non-invasive evaluation of cutaneous sensation levels with results that are objective and repeatable. Touch thresholds were assessed at the pulp of digits II and V, bilaterally. Symptoms and signs related to the vibrotactile perception thresholds and monofilament testing were related to different indices of vibration exposure.

### 4.2.4 Results

In the vibration exposed group only three subjects started their vibration exposure before 2001. 11/144 workers reported tingling sensations, 14/144 numbness and 2/144 both tingling sensations and numbness in their fingers. These symptoms, however, did not interfere with work or leisure activities. The number of subjects who displayed abnormal results on monofilament testing was 15 for digit II and 8 for digit V on the right hand, and 12 and 9, respectively, on the left hand. Three subjects showed tingling sensations and a pathologic monofilament test, one subject numbness and a pathologic monofilament test. The same tendency was noted for the vibrotactile threshold testing. Significantly increased ($p=0.04$) vibration thresholds in the vibration exposed group were found for dig II bilaterally (125 Hz). Two subjects displayed tingling sensations and three subjects numbness as well as increased vibration thresholds in dig II in the right or left hand. Three subjects were classified as 1SN and one as 2SN by the Stockholm Workshop Scale (SWS). In the non-exposed reference group 4/61 started to work before 2001. 7/61 reported tingling sensations and 4/61 numbness in their fingers, symptoms that did not disturb work or leisure activities. Abnormal results for monofilament testing in digits II and V on the right hand were found for 4 and 2 subjects, respectively. Corresponding figures for digits II and V on the left hand were 7 and 5,

respectively. The same picture was noted for vibration threshold testing. All referents were classified as 0SN (SWS).

### 4.2.5 Discussion and conclusions

This is a young cohort with a fairly short vibration exposure. Most of them have only been working for a couple of years. This is probably the main reason for the sparse findings when performing the neurophysiologic testing as shown above. Previous micro-neurographic recordings from single mechanoreceptive afferents of the human hand indicate that frequencies in the range 5 – 50 Hz and above 50 Hz are mediated by SA, FAI and FAII units, respectively [2]. FAII units are most easily excited at frequencies ranging from 100 to 300 Hz. Thus, the chosen frequencies for the vibrotactile threshold testing, 31.5 and 125 Hz, respectively, are covering the critical response intervals of these mechanoreceptors. Earlier studies have shown that these measurements can be a reliable assessment if an initial practice is included as part of the standard administration [3]. In summary, this cohort is a unique opportunity for future investigations, as we will try to follow this group for the years to come. That will enable us to detect and evaluate early discrepancies as regards neurophysiological symptoms and signs in vibration exposed workers.

### 4.2.6 References

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## 4.3 Grading of sensorineural disturbances according to the Stockholm workshop scale using self-reports - A proposal

### 4.3.1 Introduction

It is well known that vibration induced neuropathy in the hand, most often manifested as reduced sensibility (numbness) and clumsiness in hand movement, reduce work ability as well as life quality. In order to grade the severity of the dysfunction the Stockholm Workshop scale for grading sensorineural disorders (Table 6) has been widely used [1]. The grading

scale have four discrete stages, i.e. SN0-SN3, based on a progression of complaints of intermittent numbness, with or without tingling (paresthesia), sensory deficiency, and reduced performance in fine motor tasks.

Table 6. The Stockholm workshop scale for grading sensorineural disorders in vibration-exposed persons [1].

| **Stage** [a] | **Description** |
|---|---|
| 0SN | Vibration-exposed but no attacks |
| 1SN | Intermittent numbness, with and without tingling |
| 2SN | Intermittent or persistent numbness, reduced sensory perception |
| 3SN | Intermittent or persistent numbness, reduces tactile discrimination and/or manipulative dexterity |

[a] The sensorineural stages is to be established for each hand.

However, in accordance with our experience when conducting epidemiological investigations on vibration exposed groups the practical application of the grading scale has shown some difficulties. One reason is the lack of clear and generally accepted case definitions for the three symptomalogical stages. It is thus not clear whether the grading scale can, or should be adopted solely on the basis of symptom or if dysfunctions should be based also on quantitative sensory testing (QST). Another problem is that the assumed progression of symptoms, or signs, are not followed in many cases. For instance, indication of reduced manipulative dexterity and/or reduced sensory perception may be present but without complaints of intermittent or persistent numbness. Since elevated vibration perception thresholds not necessarily coincide with numbness, either during the day or at night, such cases cannot be properly classified according to the current grading scale.

There are several available and possible methods for QST that may be used, such as vibrotactile perception thresholds (VPT), thermotactile perception thresholds (TPT), two-point discrimination test (2-PD), purdue pegboard test for manual dexterity (PPB), monofilaments (MF) and more. All these types of QST demands equipment, some of which are quite sofisticated and expensive. In general, QST is most often rather time consuming to perform and requires well-trained personnel for the testing in a clinical and/or research setting.

For all epidemiological investigations that we have conducted over the last 15-20 years we have addressed symptoms and signs of sensorineural disorders by means of individual questionnaires, physical examination and testing (eg. QST). For reasons mentioned earlier and our experience a modified grading scale using self-reports has been outlined (Table 7).

The grading scale is based on three specific questions believed to be relatively good markers for complaints of intermittent numbness, sensory deficiency, and reduced performance in fine motor tasks. Moreover, a fifth stage (i.e SN4) is added allowing the situation that symptoms of reduced manipulative dexterity and/or reduced sensory perception may be present without complaints of numbness.

Table 7. Proposal for grading of sensorineural disorders in vibration-exposed persons using self-reports.

| | Nocturnal numbness | Drop things easy | Difficulty with buttoning |
|---|---|---|---|
| **SN0** | - | - | - |
| **SN1** | +<br>-<br>- | -<br>+<br>- | -<br>-<br>+ |
| **SN2** | +<br>+ | +<br>- | -<br>+ |
| **SN3** | - | + | + |
| **SN4** | + | + | + |

The objectives of the present study are to apply, on a group of vibration exposed individuals, the proposed sensorineural grading scale using; i) self-reports only, and ii) data from objective testing.

### 4.3.2 Methods

#### *4.3.2.1 Subjects*

From enrollment lists from vocational schools programs (auto mechanic, construction, and restaurant) in northern and western Sweden 3300 students that graduated 2001-2003 were asked to answer a screening questionnaire. 1868 (57%) persons responded (1561 men and 307 women). Of these 1029 persons approved to participate in further research studies. They were given a baseline self-administered questionnaire developed within the VIBRISKS project. This questionnaire was answered by 808 persons (response rate: 79%). From the final study group 208 young persons, with different individual levels of HTV exposures, were enlisted in a subcohort. Effect measurements included for instance physical examination and QST (eg. vibrotactile perception thresholds, Purdue Pegboard testing). A complete set of data was present for 126 person and they was thus included in the final data analysis.

#### *4.3.2.2 Data collection and grading*

*Grading using self reports*. Three specific questions, believed to be relatively good markers for complaints of intermittent numbness, sensory deficiency, and reduced performance in fine motor tasks, were picked out from the self-administered questionnaire developed within the

VIBRISKS project. The questions were “Numbness in hand or fingers at night?”, “Drop things easy?” and “Difficulty with buttoning?”. Answers were given for both left and right hand on a four graded scale; ”No”, ”Insignificant”, ”Some” and ”Rather much”. In the process of grading the individual answers were however dicotomized; “No” as “-” and “Insignificant” through “Rather much” as “+”.

*Grading using quantative sensory testing*. Vibrotactile thresholds, aimed to address the component “Reduced sensory perception” in SN2 in the Stockholm workshop grading scale (Table 6), were obtained with HVLab *Tactile Vibrometer*. Measurements were made on the tip of digits 2 and 5 on both left and right hand at 32 Hz and at 125 Hz, i.e 4 measurements for each hand. The individual test result for each measurement point and test frequency was considered as un-normal if the recorded threshold was higher than the study group’s mean + 1Sd. The case definition for reduced sensory perception (+) was minimum 2 un-normal thresholds. The Purdue Pegboard (Model 32020, Lafayette Instrument) measures two types of dexterity; 1) gross movements of the fingers, hands and arms; 2) fine fingertip dexterity necessary in assembly tasks. So, the result from this test may thus address the component “Reduced tactile discrimination and/or manipulative dexterity” stated in SN3 in the Stockholm workshop grading scale (Table 6). The test procedure followed the test protocol provided by the manufacturer. The case definition for reduced manipulative dexterity (+) was when the number of correctly placed pins after 30 secs fell below the study group’s mean + 1Sd (Mean≈13,9 $Pins_{30s}$, 1Sd≈1,9). The case definition for intermittent numbness (+) was the same as for grading using self reports (se above).

The sensorineural grading for each individual was then conducted in accordance with Table 7.

### 4.3.3 Results

Table 8 and 9 show crosstabulated frequencies of SN-stages and correlation, respectively, as a result of the two models for sensorineural grading. As can be seen in Table 3 about 58-60% are graded equally. Grading using QST do however result in a 3-4 times higher frequency of SN1. This is predominantly due to higher frequency of PPB cases compared to cases having difficulcies with buttoning. Despite this, the outcome of the two grading methods seems to be relatively well correlated (Table 8).

Table 8. Crosstabulated frequencies of SN-stages graded using self reports or using quantative sensory testing (QST).

| | | Using QST | | | | | |
|---|---|---|---|---|---|---|---|
| **Using self report** | | **SN0** | **SN1** | **SN2** | **SN3** | **SN4** | **Total** |
| **Left hand** | **SN0** | 65 | 26 | | 5 | | 96 |
| | **SN1** | 7 | 9 | 2 | 1 | | 19 |
| | **SN2** | | 1 | 2 | | 1 | 4 |
| | **SN3** | 1 | 1 | | | | 2 |
| | **SN4** | | 2 | 3 | | | 5 |
| | **Total** | 73 | 39 | 7 | 6 | 1 | 126 |
| **Right hand** | **SN0** | 65 | 25 | | 5 | | 95 |
| | **SN1** | 8 | 6 | 3 | | 1 | 18 |
| | **SN2** | | 3 | 1 | | | 4 |
| | **SN3** | 2 | | | | | 2 |
| | **SN4** | | 2 | 2 | | 1 | 5 |
| | **Total** | 75 | 36 | 6 | 5 | 2 | 124 |

Table 9. Correlation between SN-stages graded using self reports or using quantative sensory testing (QST).

| **Using self report** | **Using QST** | **Left hand** | **Right hand** |
|---|---|---|---|
| **Left hand** | Spearman's rho | .404** | |
| | Sig. (1-tailed) | .000 | |
| | N | 126 | |
| **Right hand** | Spearman's rho | | .341** |
| | Sig. (1-tailed) | | .000 |
| | N | | 124 |

** *Correlation is significant at the 0.01 level (1-tailed).*

#### *4.3.3.1 Discussion*

As earlier mentioned, a grading of sensorineural disturbances in according with the current Stockholm Workshop scale involves difficulties in some cases. One reason is the grading scale's progressiveness, i.e that symptoms of sensorineural disturbances due to exposure to hand-transmitted vibration developes in compliance with a predetermined pattern. This

progressive pattern is, on the basis of our experience, not followed in all cases. Thus, the grading scale for sensorineural disturbances must therefore be built up on the basis of other grounds then a progressive development of symptoms. The grading scale must consequently allow different combinations of symptoms.

Another issue is if the grading must be based on objective findings via results from quantitative sensory testing or if the grading can be based solely on self reported symptoms. The disadvantages with the former are the need for personnel resources for conducting time consuming testing and the requirement for testing equipment. The advantage with the latter is that the grading can be based on self reported data in a questionnaire or an interview.

The context in which the grading is to be done is also an issue of importance, eg for screening, health surveillance, legal compensation or research settings. The use of QST may be well justified for at least the last two mentioned purposes. This is also facilitated by the fact that the affected person will meet occupational professionals in these situations. At screening and health surveillance, however, the situation is or may be different (eg. long distances, large and wide spread study group, etc.). In this case the possibility of conducting grading through self reporting would be of great value.

The outcome of this evaluation has showed that 58-60% are graded equally by the two methods for grading. The two grading methods seem to be relatively well correlated and the result is thus encouraging. However, it may be possible to approve the correlation between the two grading methods by adjusting the used case definitions. The prevalence of sensorineural disturbances in various stages within the present study population was however to low to allow such comparisons. The two gradings methods should therefore be applied on a larger, more vibration exposed and more symptomatic study group, compared with the present study group, before any far-reaching conclusions can be made. The present proposal for grading using self reports should thus be considered more as a conceptual idea for how grading using self reports may be done.

### 4.3.4 References

1. Brammer T, Taylor W and Lundborg G. *Sensorineural stages of the hand-arm vibration syndrome.* Scand J Work Environ Health, 1987, **13**: p. 279-283.

## 4.4 Finger systolic blood pressure among young adults in relation to gender and hand-transmitted vibration

### 4.4.1 Introduction

Measurement of finger systolic blood pressure can be a way to objectify vascular disorder caused by hand-transmitted vibration [1]. The pathogenic mechanism of VWF is not completely understood but digital artery vasospasm is a probable cause. Whether there is a dose-response relationship between exposure to hand-transmitted vibration and finger systolic blood pressure reaction to local cooling is still unclear. Furthermore, whether gender or individual factors affect a probable dose-response relationship is not known.

### 4.4.2 Objectives

To study the association between finger systolic blood pressure and vibration exposure in addition to gender and individual factors.

### 4.4.3 Population and methods

A study group of 206 young persons were enlisted in a sub-cohort for physical examination and investigations. They were selected based on self reported exposure to hand-transmitted vibration (HTV) in the previous questionnaire, to ensure to have different exposure levels in the study group. The mean age of males was 21.7 years (range 20-25 years) and the mean age for females was 22.0 (range 20-23 years). Effect measurements included physical examination and testing. Exposure and health history was obtained by questionnaires and interviews according to the VIBBRISKS Protocol for Epidemiological Studies of Hand-transmitted vibration (www.vibrisks.soton.ac.uk).

### 4.4.4 FSP procedure

Finger systolic blood pressure (FSBP) was measured using in the 3$^{rd}$ finger (middle finger) on the right hand on 206 subjects. Measurements were performed according to the VIBBRISKS Protocol for Epidemiological Studies of Hand-transmitted vibration (www.vibrisks.soton.ac.uk). Percentage of finger systolic blood pressure (%FSBP) was calculated as FSBP at 10 degrees cooling divided by FSBP at 30 degrees thermal provocation times 100. Two instruments were used, a) a five channel plethysmograph (HV Lab, IVSR, Southampton, UK) b) a two channel plethysmograph developed by Department Clinical Physiology at Sahlgrenska University Hospital, Göteborg, Sweden. Room temperature was kept at 22 degrees (quartile 1 and 3: 21,4-22,4) using HV Lab instrument and at 18 degrees (quartile 1 and 3: 17.9-18.8) using Clinical Physiology instrument. The

reason for the two different temperatures was that the two instruments have standards and reference values for the different room temperatures.

### 4.4.5 Statistics

Descriptive statistics and multiple linear regressions were computed using SAS 8.4 [2].

### 4.4.6 Results

For the 162 males with vibration exposure the mean FSBP 10 degrees was 93.5 mm Hg (95% CI 89.4-97.6) and for the 7 females with vibration exposure the FSBP was 74.4 mm Hg (95% CI 59.2-89.6). The mean maximal weighted acceleration for any tool used by the subjects was for the exposed females 3.1 and males 5.4. In a linear multiple regression using FSBP as the dependent variable vibration exposure dose, room temperature and gender were significant factors (Table 10). Vibration exposure dose calculated as maximal weighted any tool, or maximal weighted A(8) or current weighted were significant in the regressions. However, neither duration nor duration times vibration level as measures of vibration exposure dose were significant in the regressions.

If only vibration exposed subjects were entered into the regression the significant relation between FSBP and maximal weighted acceleration persisted. We found no significant relations between FSBP and outside temperature and nicotine use.

Table 10. Multiple linear regressions of FSBP (mm Hg) digiti 3 right hand as dependent variable as a function of gender (male=0, female=1), age, room temperature (degrees Celsius) and vibration exposure dose defined in different ways. Parameter estimate given/ probability.

| Vibration dose definition | Intercept | Gender | Age | Room temperature | Vibration dose | R-squared |
|---|---|---|---|---|---|---|
| Duration (hours) | 20.8/0.6 | -11.8/0.06 | 0.32/0.87 | 3.34/0.002 | -0.0007/0.6 | 0.10/0.0005 |
| Weighted acceleration x duration | 25.4/0.5 | -12.5/0.05 | 0.26/0.90 | 3.21/0.002 | -0.0003/0.25 | 0.10/0.0003 |
| Maximal weighted acceleration any tool | 45.0/0.25 | -19.7/0.004 | -0.08/0.97 | 3.10/0.002 | -2.30/0.006 | 0.13/0.0001 |
| Maximal weighted acceleration A(8) each tool | 27.4/0.48 | -15.3/0.02 | 0.50/0.80 | 3.04/0.003 | -5.24/0.03 | 0.12/0.0001 |
| Current weighted acceleration A(8) | 29.1/0.45 | -16.3/0.01 | 0.41/0.83 | 3.07/0.002 | -4.87/0.004 | 0.14/0.0001 |

### 4.4.7 References

1. Bovenzi, M., *Finger systolic blood pressure indices for the diagnosis of vibration-induced white finger.* Int Arch Occup Environ Health, 2002. **75**(1-2): p. 20-8.

2. SAS Institute Inc, *SAS/STAT.* User's guide, version 8, 1999: p. 1-3384.

## 4.5 Vibrotactile and thermotactile perception threshold

Results from vibrotactile and thermotactile perception threshold measurements conducted on subjects within the Swedish baseline sub cohort is shown in Table 17 and 18. Mean and standard deviations are shown for two exposure categories – one denoted “Not or very low vibration exposed” and the other “vibration exposed”. Measurements of thresholds have been conducted on the tip of digits II and V on both left and right hands. Results for thermotactile perception is presented in terms of the “neutral zone” (NZ), i.e. the difference between the absolute thresholds for heat and cold.

Table 17. Vibrotactile perception thresholds

| VIBROTACTILE PERCEPTION THRESHOLD ($m/s^2$) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Left hand | | | Right hand | | |
| Frequency | Dig | N | Mean | Sd | N | Mean | Sd |
| Non or very low vibration exposed group | | | | | | | |
| 32 | II | 73 | 0.139 | 0.108 | 73 | 0.169 | 0.132 |
| 125 | II | 73 | 0.170 | 0.109 | 73 | 0.217 | 0.136 |
| 32 | V | 73 | 0.157 | 0.075 | 72 | 0.197 | 0.128 |
| 125 | V | 70 | 0.258 | 0.206 | 71 | 0.274 | 0.196 |
| Vibration exposed group | | | | | | | |
| 32 | II | 113 | 0.165 | 0.104 | 112 | 0.177 | 0.100 |
| 125 | II | 113 | 0.246 | 0.188 | 112 | 0.294 | 0.205 |
| 32 | V | 112 | 0.201 | 0.130 | 113 | 0.207 | 0.134 |
| 125 | V | 110 | 0.317 | 0.253 | 112 | 0.391 | 0.347 |

Table 18. Thermotactile perception threshold in term of neutral zones for heat and cold.

| NEUTRAL ZONE FOR THERMOTACTILE PERCEPTION (Degrees) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Left hand | | | Right hand | | |
| | Dig | N | Mean | Sd | N | Mean | Sd |
| Non or very low vibration exposed group | | | | | | | |
| | II | 77 | 6.29 | 3.39 | 77 | 5.84 | 3.07 |
| | V | 77 | 7.59 | 3.87 | 77 | 7.87 | 3.76 |
| Vibration exposed group | | | | | | | |
| | II | 129 | 6.92 | 3.34 | 128 | 6.79 | 2.75 |
| | V | 129 | 8.02 | 3.83 | 129 | 8.26 | 4.01 |

As can be seen in tables above the vibrotactile thresholds for the exposed group is somewhat higher which may indicate a negative effect due to vibration exposure. Also, the the neutral zone for thermotactile perception is somewhat wider for the exposed group which may support this idea. Further analysis of data is however needed before any conclusion can be drawn whether this tendency towards a negative effect is due to vibration exposure, any other factor or a combination of several contributing factors.

# 5 Incidence of vascular, sensorineural, and musculoskeletal symptoms at the follow up survey(s) of the study population

Table 11. At baseline the persons either have symptoms or not. In the table are presented the percentage of each of these categories having symptoms at follow-up.

| | Referents Men | | HTV exposed Men | | Referents Women | | HTV exposed Women | |
|---|---|---|---|---|---|---|---|---|
| **Baseline** | *N* | **%** | *N* | **%** | *N* | **%** | *N* | **%** |
| **Numbness in hands/fingers at night** | | | | | | | | |
| **0** | *35* | 6 | *215* | 5 | *91* | 10 | *3* | 0 |
| **1** | *1* | 100 | *18* | 17 | *7* | 57 | *3* | 67 |
| **No power in handgrip** | | | | | | | | |
| **0** | *33* | 6 | *216* | 4 | *89* | 9 | *5* | 20 |
| **1** | *3* | 33 | *17* | 41 | *11* | 36 | *1* | 100 |
| **Easy to drop objects** | | | | | | | | |
| **0** | *33* | 0 | *224* | 3 | *90* | 4 | *4* | 0 |
| **1** | *1* | 0 | *7* | 14 | *10* | 40 | *2* | 50 |
| **Pain in wrist** | | | | | | | | |
| **0** | *33* | 12 | *194* | 6 | *71* | 24 | *3* | 33 |
| **1** | *3* | 0 | *37* | 49 | *27* | 48 | *3* | 100 |
| **Pain in finger** | | | | | | | | |
| **0** | *32* | 6 | *199* | 5 | *91* | 5 | *4* | 0 |
| **1** | *3* | 0 | *35* | 29 | *7* | 57 | *2* | 100 |
| **Coldness in hands/fingers** | | | | | | | | |
| **0** | *35* | 6 | *190* | 5 | *87* | 15 | *4* | 0 |
| **1** | *2* | 50 | *41* | 46 | *12* | 0 | *2* | 100 |
| **Whiteness in one or more fingers when cold or damp** | | | | | | | | |
| **0** | *35* | 3 | *202* | 4 | *87* | 1 | *4* | 0 |
| **1** | *2* | 50 | *29* | 67 | *13* | 46 | *2* | 50 |
| **Hard to button** | | | | | | | | |
| **0** | *36* | 3 | *224* | 1 | *99* | 1 | *5* | 40 |
| **1** | *0* | . | *5* | 0 | *0* | . | *1* | 0 |
| **Fingers changing colour** | | | | | | | | |
| **0** | *31* | 16 | *165* | 14 | *78* | 14 | *2* | 0 |
| **1** | *6* | 50 | *86* | 60 | *25* | 60 | *4* | 50 |
| **Tingling/pricking in fingers** | | | | | | | | |
| **0** | *32* | 25 | *180* | 24 | *75* | 20 | *2* | 0 |
| **1** | *4* | 75 | *75* | 60 | *26* | 62 | *4* | 75 |
| **Neck pain (last 12 months)** | | | | | | | | |
| **0** | *30* | 17 | *202* | 19 | *78* | 18 | *4* | 0 |
| **1** | *6* | 33 | *52* | 27 | *24* | 33 | *2* | 0 |
| **Arm pain (last 12 months)** | | | | | | | | |
| **0** | *27* | 0 | *191* | 0 | *70* | 0 | *6* | 0 |
| **1** | *7* | 100 | *49* | 100 | *27* | 100 | *0* | . |

# 6 Metrics of vibration exposure and ergonomic risk factors used according to HTV operative manual

Results from the Swedish SAQ HTV cohort.

## 6.1 Metrics of vibration exposure in the Swedish SAQ HTV cohort

Table 12. Characteristics of controls and HTV workers for baseline dose 1 - 14.

| | Control* | | HTV workers* | |
|---|---|---|---|---|
| | N | Mean (SD) | N | Mean (SD) |
| Dose 1 | 440 | 88.88 (397.69) | 66 | 2566.29 (4918.55) |
| Dose 2 | 440 | 116.96 (282.54) | 66 | 9109.07 (19396.58) |
| Dose 3 | 440 | 469.28 (1368.31) | 66 | 38460.12 (80548.12) |
| Dose 4 | 440 | 13408.22 (54024.70) | 66 | 881223.24 (1693703.22) |
| Dose 8 | 440 | 1.50 (2.36) | 66 | 5.18 (1.76) |
| Dose 10 | 440 | 0.78 (1.87) | 66 | 3.83 (2.86) |
| Dose 11 | 440 | 57.43 (207.24) | 66 | 186.44 (137.60) |
| Dose 12 | 339 | 0.44 (0.88) | 66 | 2.35 (1.38) |
| Dose 14 | 338 | 0.22 (0.68) | 66 | 2.26 (1.80) |

SD – Standard deviation

* Controls: dose 2 <= 1600, HTV workers: dose 2 > 1600.

Table 11 Baseline. Percentages in different categories for the ergonomic factors.

| % | Referents | | | | | Exposed | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***N*** | **Never** | **1-4 times per day** | **5-20 times per day** | **More than 20 times per day** | **N** | **Never** | **1-4 times per day** | **5-20 times per day** | **More than 20 times per day** |
| **How many times per day do you perform long lasting or frequently occurring work with your back ...** | | | | | | | | | | |
| Bent forward, backwards or sideways? | *230* | 15 | 29 | 21 | 35 | 496 | 8 | 24 | 31 | 36 |
| Twisted? | *221* | 29 | 32 | 20 | 19 | 477 | 14 | 33 | 29 | 24 |
| Bent and twisted at the same time? | *224* | 33 | 33 | 16 | 19 | 480 | 16 | 39 | 25 | 20 |
| **How many times per day is your neck repeatedly or under longer periods ...** | | | | | | | | | | |
| Bent forward, backwards or sideways? | *228* | 13 | 26 | 30 | 31 | 495 | 10 | 25 | 34 | 31 |
| Twisted? | *221* | 24 | 27 | 24 | 24 | 480 | 12 | 29 | 28 | 31 |
| Bent and twisted at the same time? | *221* | 29 | 32 | 20 | 18 | 481 | 16 | 32 | 28 | 24 |
| **How many times per day do you perform long lasting or frequently occuring work with your arms forward, without support at the sides or arms above the shoulders...** | | | | | | | | | | |
| | *226* | 23 | 32 | 18 | 27 | 496 | 12 | 28 | 28 | 32 |

| % | Referents | | | | | Exposed | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ***N*** | **Never** | **1-4 times per day** | **5-20 times per day** | **More than 20 times per day** | **N** | **Never** | **1-4 times per day** | **5-20 times per day** | **More than 20 times per day** |
| **How many times per day do you repeatedly perform work with your arms and hands that involve …** | | | | | | | | | | |
| Twisted movements? | *225* | 19 | 29 | 23 | 28 | 487 | 11 | 23 | 27 | 39 |
| Powerful movements? | *224* | 25 | 33 | 23 | 19 | 478 | 11 | 25 | 29 | 35 |
| Uncomfortable hand positions or grip? | *223* | 30 | 31 | 21 | 19 | 479 | 14 | 34 | 28 | 25 |
| High demands on precision? | *223* | 37 | 25 | 19 | 19 | 479 | 13 | 33 | 23 | 32 |
| **If manual lifting, how many times per day …** | | | | | | | | | | |
| Are you lifting? | *226* | 15 | 28 | 26 | 32 | 485 | 6 | 27 | 32 | 35 |
| Lifting objects weighing 10kg or more? | *221* | 26 | 43 | 21 | 10 | 483 | 9 | 34 | 35 | 22 |
| Lifting objects weighing 25kg or more? | *223* | 53 | 34 | 9 | 4 | 477 | 20 | 49 | 23 | 8 |
| Handling objects under knee height? | *221* | 29 | 36 | 24 | 11 | 481 | 15 | 42 | 29 | 14 |
| Handling objects over shoulders? | *223* | 36 | 34 | 19 | 11 | 476 | 20 | 41 | 27 | 13 |
| Often hard to get grip of the objects? | 222 | 63 | 28 | 5 | 4 | 472 | 45 | 41 | 11 | 3 |

| % | Referents | | | | | Exposed | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | Never, almost never | A couple of days per month | A couple of days per week | Every day, almost every day | N | Never | 1-4 times per day | 5-20 times per day | More than 20 times per day |
| **How frequently occurring during a day are repeatedly, long lasting or uncomfortable carrying, pushing or dragging of objects?** | | | | | | | | | | |
| | 224 | 39 | 35 | 14 | 12 | 491 | 18 | 46 | 23 | 13 |
| **Have you, during the last month, performed tasks where the same hand and finger movements are repeated many times per minute for totally more than half an hour each day?** | | | | | | | | | | |
| | 225 | 38 | 18 | 11 | 33 | 490 | 28 | 17 | 16 | 39 |
| **Have you, during the last month, performed tasks of precision for totally more than half an hour each day?** | | | | | | | | | | |
| | 222 | 52 | 17 | 14 | 17 | 489 | 40 | 22 | 14 | 24 |

## 6.2 Postural stress and neck pain

The aim was to explore associations between neck pain and postural stressors among young adults based on data obtained from HTV base-line self-administered questionnaire. The questionnaire includes a total of 20 questions related to postural stress and ergonomic conditions. Three different exposure indices were constructed: neck posture (4 questions), hand-intensive work (5 questions) and a total ergonomic exposure index consisting of all 20 questions. The index scores were calculated as the sums of the single item score. The internal consistency of the indicies were tested with Cronbach's Alpha. All three indices had alpha scores >= 0.85, indicating a good internal consistency. The items from which the indices were constructed were decided a priori based on the authors knowledge and observations described in the scientific literature as risk factors for neck pain, for example the items included in the neck index were three questions regarding neck postures and one question regarding work with hands above shoulder level. Based on the scores in the different indicies four exposure categories were formed based on the distribution. Three different time aspects of neck pain was assessed. First, respondents answered if they had ever experienced pain in the neck, and then if they had experienced pain the last seven days or during the past 12 months.

The prevalence was calculated as the ratio between the number of respondents with neck pain and the total number of respondents. Logistic regression was used to calculate the risk of the different exposure variables and presented as odds ratios (OR) with 95 percent confidence intervals (95% CI). All analyses were stratified by gender.

The prevalence of ever having experienced neck pain was 41.1% for the men and 58.8% for the women. Neck pain the last seven days was reported by 16.3% of the men and 31.8% of the women.

All three exposure indices showed increased odds ratios among the highest exposed for having experienced neck pain ever and neck pain the past week (Table 14, data only shown for men). Dose-response relations were observed in all three exposure indices.

Table 14**.** Univariate association between neck pain and the different ergonomic exposure indices for men. Presented as odds ratios (OR) and 95% confidence intervals (95% CI).

| | **Neck pain ever** | | | **Neck pain last 7 days** | |
|---|---|---|---|---|---|
| **Exposure variables** | OR | 95% CI | n | OR | 95% CI |
| Neck posture [n=545] | | | | | |
| Reference (0-4) | 1.0 | -- | 166 | 1.0 | -- |
| Low (5-7) | 2.0 | 1.19-3.3 | 125 | 1.9 | 0.94-4.1 |
| Medium (8-9) | 2.4 | 1.43-4.0 | 114 | 2.5 | 1.20-5.1 |
| High (10-12) | 3.7 | 2.31-6.1 | 140 | 3.2 | 1.68-6.6 |
| Hand-intensive work [n=540] | | | | | |
| Reference (0-5) | 1.0 | -- | 140 | 1.0 | -- |
| Low (6-8) | 1.6 | 0.97-2.8 | 119 | 1.4 | 0.63-3.3 |
| Medium (9-11) | 1.6 | 0.94-2.7 | 124 | 2.6 | 1.24-5.5 |
| High (12-15) | 3.4 | 2.10-5.6 | 157 | 3.3 | 1.70-6.9 |
| Total ergonomic exposure [n=535] | | | | | |
| Reference (0-21) | 1.0 | -- | 134 | 1.0 | -- |
| Low (22-31) | 2.0 | 1.21-3.4 | 138 | 2.0 | 0.90-4.6 |
| Medium (32-41) | 2.0 | 1.20-3.5 | 128 | 2.7 | 1.27-6.2 |
| High (42-60) | 4.3 | 2.58-7.3 | 135 | 4.1 | 1.97-9.0 |

# 7 Possible exposure-response (for symptoms) or dose-effect (for objective test results) relationships at the cross-sectional survey

Results from the Swedish SAQ HTV cohort. In addition, See 1.2.3 Main results of objective tests at the cross-sectional survey.

Table 15. Odds Ratios and 95 % confides interval of baseline symptoms for HTV workers/controls and male/female.

| **Symptoms** | **HTV workers / Controls** | | **Male / Female** | |
|---|---|---|---|---|
| **Hand** | **OR** | **95 % CI** | **OR** | **95 % CI** |
| Numbness in hands/fingers at night | 6.184 | 1.934, 19.773 | 0.153 | 0.049, 0.481 |
| No power in handgrip | 1.709 | 0.632, 4.619 | 0.411 | 0.148, 1.147 |
| Easy to drop objects | 2.020 | 0.594, 6.875 | 0.180 | 0.053, 0.613 |
| Pain in wrist | 2.068 | 0.998, 4.285 | 0.261 | 0.124, 0.552 |
| Pain in finger | 1.778 | 0.764, 4.140 | 0.736 | 0.295, 1.839 |
| Coldness in hands/fingers | 1.941 | 0.901, 4.180 | 0.488 | 0.218, 1.093 |
| Whiteness in one or more fingers when cold or damp | 2.999 | 1.202, 7.480 | 0.332 | 0.130, 0.845 |
| Hard to button | 27.463 | 1.900, 396.893 | 0.183 | 0.024, 1.385 |
| Fingers changing colour | 2.109 | 1.195, 3.724 | 0.599 | 0.324, 1.108 |
| Tingling/pricking in fingers | 2.109 | 1.204, 3.694 | 0.492 | 0.270, 0.897 |
| **Neck** | | | | |
| Neck pain (last 12 months) | 1.068 | 0.613, 1.861 | 0.871 | 0.474, 1.602 |
| **Arm / shoulder** | | | | |
| Arm pain (last 12 months) | 0.678 | 0.328, 1.401 | 1.489 | 0.692, 3.202 |
| Shoulder/over arm pain (last 12 months) | 0.623 | 0.295, 1.315 | 1.580 | 0.715, 3.493 |
| Elbow/under arm pain (last 12 months) | 1.520 | 0.483, 4.781 | 1.129 | 0.334, 32 |

# 8 Possible exposure-response (for symptoms) or dose-effect (for objective test results) relationships for the changes in the outcomes over time during the follow up period(s)

Results from the Swedish SAQ HTV cohort.

**Table 1** OR of symptoms. Note that gender and exposure is to some extent not separable. Men are mostly exposed and women are mostly referents. Gender is not included in the model as gender and exposure then is a source for multicolinearity.

| | **HTV exposed /Referents** | | | | | |
|---|---|---|---|---|---|---|
| | **Baseline=0** | | | **Baseline=1** | | |
| | *N* | **OR** | **95% CI** | *N* | **OR** | **95% CI** |
| **Numbness in hands/fingers at night** | *344* | 0,56 | 0,234 ; 1,32 | *29* | 0,19 | 0,033 ; 1,08 |
| **No power in handgrip** | *323* | 0,53 | 0,215 ; 1,31 | *32* | 1,4 | 0,343 ; 6,05 |
| **Easy to drop objects** | *341* | 0,80 | 0,223 ; 2,90 | *20* | 0,50 | 0,068 ; 3,68 |
| **Pain in wrist** | *301* | 0,28 | 0,133 ; 0,584 | *70* | 1,4 | 0,558 ; 3,74 |
| **Pain in finger** | *310* | 0,77 | 0,279 ; 2,12 | *47* | 0,72 | 0,171 ; 3,04 |
| **Coldness in hands/fingers** | *291* | 0,39 | 0,168 ; 0,893 | *57* | 12,4 | 1,49 ; 103,37 |
| **Whiteness in one or more fingers when cold or damp** | *317* | 2,7 | 0,582 ; 12,9 | *46* | 2,4 | 0,678 ; 8,49 |
| **Hard to button** | *358* | 1,2 | 0,214 ; 6,54 | *0* | . | . |
| **Fingers changing colour** | *237* | 0,93 | 0,466 ; 1,85 | *49* | 1,1 | 0,473 ; 2,48 |
| **Tingling/pricking in fingers** | *222* | 1,2 | 0,657 ; 2,06 | *109* | 0,90 | 0,376 ; 2,14 |
| **Neck pain (last 12 months)** | *256* | 1,1 | 0,597 ; 2,00 | *84* | 0,70 | 0,265 ; 1,85 |
| **Arm pain (last 12 months)** | *131* | 0,93 | 0,397 ; 2,18 | *59* | 0,50 | 0,176 ; 1,44 |

# 9 Appendix VIBIT questionnaire (only available in Swedish)

## Först några frågor om Dig själv

**1. Vilken är Din (huvudsakliga) sysselsättning för närvarande?**

☐ 1 Studerande
☐ 2 Arbetssökande
☐ 3 Sjukskriven
☐ 4 Fast anställning
☐ 5 Tidsbegränsad anställning
☐ 6 Egen företagare
☐ 7 Värnpliktig
☐ 8 Långtidsresa
☐ 9 Annat, **Vad?** .....
7
.....

**2.Vad tror Du blir Din (huvudsakliga) sysselsättning under det kommande året?**

☐ 1 Studerande
☐ 2 Arbetssökande
☐ 3 Sjukskriven
☐ 4 Fast anställning
☐ 5 Tidsbegränsad anställning
☐ 6 Egen företagare
☐ 7 Värnpliktig
☐ 8 Långtidsresa
☐ 9 Annat, **Vad?** .....
9
.....

**3. Hur lång är Du?**

9 ☐☐☐ centimeter

**4. Hur många kilo väger Du?**

12 ☐☐☐ kilo

**5. Har Du rökt dagligen eller nästan dagligen under de senaste 7 dagarna?**

☐ 1 Ja
☐ 2 Nej
15

**6. Har Du snusat dagligen eller nästan dagligen under de senaste 7 dagarna?**

☐ 1 Ja
☐ 2 Nej
16

**7. Är Du nykterist (dricker aldrig alkohol)?**

☐ 1 Ja
☐ 2 Nej
17

**8. Har Du svenska som modersmål?**

☐ 1 Ja
☐ 2 Nej
18

■

## Hur är Din arbetsmiljö

**1. Ungefär hur många minuter per dag är Du i geno snitt utsatt för ogynnsamma arbetsställningar?**

**Räkna med både arbetstid/skoltid och fritid!**

19 ☐☐☐ minuter per dag

**2. Ungefär hur många minuter per dag är Du i geno snitt utsatt för vibrationer från handhållna maskir som får händer och armar att skaka?**

**Räkna med både arbetstid/skoltid och fritid!**

22 ☐☐☐ minuter per dag

**3. Ungefär hur många minuter per dag är Du i geno snitt utsatt för buller eller musik i sådan omfattning Du ej kan tala i normal samtalston med personer sc står en meter bort?**

**Räkna med både arbetstid/skoltid och fritid!**

25 ☐☐☐ minuter per dag

**4. Om Du kan välja att arbeta med maskintyper sc vibrerar olika mycket.**

**Ungefär hur ofta brukar Du då välja maskintyp m hänsyn till vibrationsnivå?**

☐ 1 Alltid
☐ 2 3 av 4 gånger
☐ 3 Varannan gång
☐ 4 1 av 4 gånger
☐ 5 Aldrig
28

**5. Om Du skall arbeta i bullrande miljöer.**

**Brukar Du då normalt använda hörselskydd unc arbetstid och skoltid?**

☐ 1 Nej
☐ 2 Ja, mest kåpa
☐ 3 Ja, mest öronplugg
29

**6. Ungefär hur många minuter per dag brukar normalt använda hörselskydd under arbetstid o skoltid?**

30 ☐☐☐ minuter per dag

**7. Om Du vistas i bullrande miljöer på fritiden.**

**Brukar Du då normalt använda hörselskydd?**

☐ 1 Nej
☐ 2 Ja, mest kåpa
☐ 3 Ja, mest öronplugg
33

**8. Ungefär hur många minuter per dag brukar normalt använda hörselskydd under Din fritid?**

34 ☐☐☐ minuter per dag

Vibit, arbetsmiljö, utkast 1

**9. Ungefär hur ofta händer det att Du bränner Dig på varma föremål under arbetstid och skoltid?**

☐ 1 Flera gånger om dagen
☐ 2 En gång per dag
☐ 3 Några gånger per vecka
☐ 4 Några gånger per månad
☐ 5 Aldrig eller nästan aldrig
37

**10. När Du lyssnar på musik. Ungefär hur ofta brukar Du då tänka på risken för hörselskador när Du ställer in ljudnivån?**

☐ 1 Alltid
☐ 2 3 av 4 gånger
☐ 3 Varannan gång
☐ 4 1 av 4 gånger
☐ 5 Aldrig
38

**11. Hur orolig är Du för att Din hälsa ska påverkas av att Du använder vibrerande handhållna maskiner?**

☐ 1 Inte orolig alls
☐ 2 Lite orolig
☐ 3 Måttligt orolig
☐ 4 Mycket orolig
☐ 5 Använder inte vibrerande maskiner
39

**12. Hur orolig är Du för att Din hälsa ska påverkas av buller?**

☐ 1 Inte orolig alls
☐ 2 Lite orolig
☐ 3 Måttligt orolig
☐ 4 Mycket orolig
☐ 5 Utsätts inte för buller
40

**13. Hur orolig är Du för att Din hälsa ska påverkas av Din datoranvändning?**

☐ 1 Inte orolig alls
☐ 2 Lite orolig
☐ 3 Måttligt orolig
☐ 4 Mycket orolig
☐ 5 Använder inte dator
41

**13. Hur orolig är Du för att Din hälsa ska påverkas av elektromagnetisk "strålning" från mobiltelefoner?**

☐ 1 Inte orolig alls
☐ 2 Lite orolig
☐ 3 Måttligt orolig
☐ 4 Mycket orolig
☐ 5 Använder inte mobiltelefon
42

**14. Hur orolig är Du för att Din hälsa ska påverkas av stress i arbetet?**

☐ 1 Inte orolig alls
☐ 2 Lite orolig
☐ 3 Måttligt orolig
☐ 4 Mycket orolig
☐ 5 Är inte utsatt för stress
43

**15. Hur orolig är Du för att Din hälsa ska påverkas av - ogynnsamma arbetsställningar?**

☐ 1 Inte orolig alls
☐ 2 Lite orolig
☐ 3 Måttligt orolig
☐ 4 Mycket orolig
☐ 5 Har inte ogynsamma arbetsställningar
44

## Din användning av datorer & mobiltelefoner

**1. Har Du under *det senaste året* använt följande utrustning?**

| | | Nej (1) | Ja (2) |
|---|---|---|---|
| 45 | Vanlig bordsdator (PC) | ☐ | ☐ |
| 46 | Laptop eller bärbar PC | ☐ | ☐ |
| 47 | Web-kamera | ☐ | ☐ |
| 48 | Handdator, fickdator eller Palm pilot | ☐ | ☐ |
| 49 | Datorbok eller läsplatta | ☐ | ☐ |
| 50 | Mobiltelefon | ☐ | ☐ |
| 51 | Trådlös telefon med basenhet | ☐ | ☐ |
| 52 | TV/Video | ☐ | ☐ |
| 53 | GPS - satelitbaserat positionssystem | ☐ | ☐ |
| 54 | VR - Virtuell verklighet | ☐ | ☐ |
| 55 | Annan IT-utrustning | ☐ | ☐ |

**Berätta vilken annan IT-utrustning!**

.....

.....

**2. Hur gammal var Du när Du *regelbundet* började använda följande utrustning?**

| | Ålder | Utrustning |
|---|---|---|
| 56 | ☐☐ | Vanlig bordsdator (PC) |
| 58 | ☐☐ | Laptop eller bärbar PC |
| 60 | ☐☐ | Web-kamera |
| 62 | ☐☐ | Handdator, fickdator eller Palm pilot |
| 64 | ☐☐ | Datorbok eller läsplatta |
| 66 | ☐☐ | Mobiltelefon |
| 68 | ☐☐ | Trådlös telefon med basenhet |
| 70 | ☐☐ | TV/Video |
| 72 | ☐☐ | GPS - satelitbaserat positionssystem |
| 74 | ☐☐ | VR - Virtuell verklighet |

Vibit, arbetsmiljö, utkast 1

**3. Om Du tänker på den senaste veckan. Ungefär hur många timmar och minuter per dag har Du använt följande utrustning?**

| | Timmar | Minuter | Utrustning |
|---|---|---|---|
| 76 | ☐☐ | ☐☐ | Vanlig bordsdator (PC) |
| 80 | ☐☐ | ☐☐ | Laptop eller bärbar PC |
| 84 | ☐☐ | ☐☐ | Web-kamera |
| 88 | ☐☐ | ☐☐ | Handdator, fickdator eller Palm pilot |
| 92 | ☐☐ | ☐☐ | Datorbok eller läsplatta |
| 96 | ☐☐ | ☐☐ | Mobiltelefon *(talar i telefonen)* |
| 100 | ☐☐ | ☐☐ | Trådlös telefon med basenhet |
| 104 | ☐☐ | ☐☐ | TV/Video |
| 108 | ☐☐ | ☐☐ | GPS - satelitbaserad positionering |
| 112 | ☐☐ | ☐☐ | VR - Virtuell verklighet |

**4. Om Du tänker på den senaste veckan.**

**Ungefär hur många gånger per dag har Du - ringt eller tagit emot samtal på mobiltelefon?**

116 ☐☐☐ gånger per dag

**Ungefär hur många gånger per dag har Du - ringt eller tagit emot samtal på annan trådlös telefon?**

119 ☐☐☐ gånger per dag

**Ungefär hur många gånger per dag har Du - sänt eller tagit emot SMS-meddelande?**

122 ☐☐☐ gånger per dag

**Ungefär hur många minuter per dag har Du - använt mobiltelefon för spel?**

125 ☐☐☐ minuter per dag

**5. Om Du tänker på den senaste veckan.**

**- Har Du senaste veckan använt persondator**

☐ 1 Mer än en normal vecka
☐ 2 Ungefär samma som en normal vecka
☐ 3 Mindre än en normal vecka
128

**- Har Du senaste veckan använt mobiltelefon och annan trådlös telefon**

☐ 1 Mer än en normal vecka
☐ 2 Ungefär samma som en normal vecka
☐ 3 Mindre än en normal vecka
129

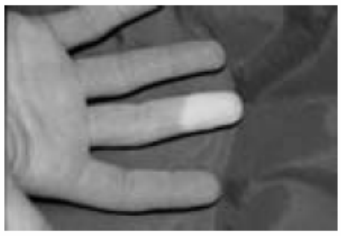
**- Har Du senaste veckan använt annan IT-utrustning**

☐ 1 Mer än en normal vecka
☐ 2 Ungefär samma som en normal vecka
☐ 3 Mindre än en normal vecka
129

## Hur är Din hälsa

**1. Har Du de senaste 30 dagarna haft något av följande?**

| | | Nej (1) | Ja (2) |
|---|---|---|---|
| 131 | Domningar i hand eller finger på natten | ☐ | ☐ |
| 132 | Värk i handled | ☐ | ☐ |
| 133 | Fryser lätt om händerna (med eller utan färgförändringar i huden) | ☐ | ☐ |
| 134 | "Vita fingrar" av typen att ett eller flera fingrar bleknar vid fukt eller kyla som på bilden | ☐ | ☐ |



**2. Har Du de senaste 30 dagarna haft nedsatt hörsel?**

☐ 1 Nej
☐ 2 Ja, bara på höger öra
☐ 2 Ja, bara på vänster öra
☐ 2 Ja, på båda öronen
135

**3. Har Du de senaste 30 dagarna haft öronsusningar?**

☐ 1 Nej
☐ 2 Ja, bara på höger öra
☐ 2 Ja, bara på vänster öra
☐ 2 Ja, på båda öronen
136

**4. Har Du mer än 7 dagar i följd det senaste året haft?**

| | | Nej (1) | Ja (2) |
|---|---|---|---|
| 137 | Hudbesvär | ☐ | ☐ |
| 138 | Ögontrötthet eller andra ögonbesvär | ☐ | ☐ |
| 139 | Värk/smärta i nacke eller övre delen av ryggen | ☐ | ☐ |
| 140 | Värk/smärta i nedre delen av ryggen | ☐ | ☐ |
| 141 | Värk/smärta i axlar, armar, handleder, händer | ☐ | ☐ |
| 142 | Domningar eller stickningar i hand och fingrar | ☐ | ☐ |

5

Vibit, arbetsmiljö, utkast 1

**5. Har Du för närvarande hudbesvär?**

143 ☐ 1 Ja
☐ 2 Nej

OM JA:

**Hur många dagar i sträck har Du haft hudbesvären?**

144 ☐☐☐ dagar i sträck

**6. Har Du för närvarande ögontrötthet eller andra ögonbesvär?**

☐ 1 Ja
147 ☐ 2 Nej

OM JA:

**Hur många dagar i sträck har Du haft ögontrötthet eller andra ögonbesvär?**

148 ☐☐☐ dagar i sträck

**7. Har Du för närvarande värk/smärta i nacke eller övre delen av ryggen?**

☐ 1 Ja
151 ☐ 2 Nej

OM JA:

**Hur många dagar i sträck har Du haft värk/smärta i nacke eller övre delen av ryggen?**

152 ☐☐☐ dagar i sträck

**8. Har Du för närvarande värk/smärta i nedre delen av ryggen?**

☐ 1 Ja
155 ☐ 2 Nej

OM JA:

**Hur många dagar i sträck har Du haft värk/smärta i nedre delen av ryggen?**

156 ☐☐☐ dagar i sträck

**9. Har Du för närvarande värk/smärta i axlar, armar, handleder eller händer?**

☐ 1 Ja
159 ☐ 2 Nej

OM JA:

**Hur många dagar i sträck har Du haft värk/smärta i axlar, armar, handleder eller händer?**

160 ☐☐☐ dagar i sträck

**10. Har Du för närvarande domningar eller stickningar i hand och fingrar?**

☐ 1 Ja
163 ☐ 2 Nej

OM JA:

**Hur många dagar i sträck har Du haft domningar eller stickningar i hand och fingrar?**

164 ☐☐☐ dagar i sträck

## Besvär som påverkat Din prestation de senaste 7 dagarna

**1. Har Din prestation de senaste 7 dagarna påverkats av hudbesvär?**

☐ 1 Ja
167 ☐ 2 Nej

OM JA:

**Hur många minuter har Du de senaste 7 dagarna förlorat i arbetet/skolan pga hudbesvären?**

168 ☐☐☐ minuter senaste 7 dagarna

**2. Har Din prestation de senaste 7 dagarna påverkats av ögontrötthet eller andra ögonbesvär?**

☐ 1 Ja
171 ☐ 2 Nej

OM JA:

**Hur många minuter har Du de senaste 7 dagarna förlorat i arbetet/skolan pga ögontrötthet eller andra ögonbesvär?**

172 ☐☐☐ minuter senaste 7 dagarna

**3. Har Din prestation de senaste 7 dagarna påverkats av värk/smärta i muskler och leder?**

☐ 1 Ja
175 ☐ 2 Nej

OM JA:

**Hur många minuter har Du de senaste 7 dagarna förlorat i arbetet/skolan pga värk/smärta i muskler och leder?**

176 ☐☐☐ minuter senaste 7 dagarna

**4. Har Din prestation de senaste 7 dagarna påverkats av oro och nedstämdhet?**

☐ 1 Ja
179 ☐ 2 Nej

OM JA:

**Hur många dagar i sträck har Du haft oro och nedstämdhet?**

180 ☐☐☐ minuter senaste 7 dagarna

**5. Har Din prestation de senaste 7 dagarna påverkats av domningar eller stickningar i hand och fingrar?**

☐ 1 Ja
183 ☐ 2 Nej

OM JA:

**Hur många minuter har Du de senaste 7 dagarna förlorat i arbetet/skolan pga domningar eller stickningar i hand och fingrar?**

184 ☐☐☐ minuter senaste 7 dagarna

6

**6. Har Din prestation de senaste 7 dagarna påverkats av annat?**

☐ 1 Ja
☐ 2 Nej
187

OM JA:

**Hur många minuter har Du de senaste 7 dagarna förlorat i arbetet/skolan pga annat?**

188 ☐☐☐ minuter senaste 7 dagarna

## Ditt allmänna hälsotillstånd

**1. Med stress menas ett tillstånd då man känner sig spänd, rastlös, nervös eller orolig eller inte kan sova på natten eftersom man tänker på problem hela tiden.**

**Känner Du av sådan stress för närvarande?**

☐ 1 Inte alls
☐ 2 Bara litet
☐ 3 I viss mån
☐ 4 Ganska mycket
☐ 5 Väldigt mycket
191

**7. Har Du under längre sammanhängande tid än 7 dagar de senaste 12 månaderna känt sådan stress?**

☐ 1 Ja
☐ 2 Nej
192

**3. Hur bedömer Du Ditt allmänna hälsotillstånd?**

☐ 1 Mycket bra
☐ 2 Ganska bra
☐ 3 Varken bra eller dåligt
☐ 4 Ganska dåligt
☐ 5 Mycket dåligt
193

**4. Har Du under de senaste 30 dagarna ofta**
**- haft minskad lust att göra saker som Du vanligen tycker om?**

☐ 1 Ja
☐ 2 Nej
194

**5. Har Du under de senaste 30 dagarna ofta**
**- känt Dig illa till mods, deprimerad eller känt att framtiden ser hopplös ut?**

☐ 1 Ja
☐ 2 Nej
195

**6. Hur ofta under de senaste 30 dagarna har Du lagt märke till att**
**- Du känner hjärtklappning eller tryck över bröstet?**

☐ 1 Aldrig
☐ 2 Någon enstaka gång
☐ 3 Några gånger i veckan
☐ 4 En eller flera gånger per dag
196

**7. Hur ofta under de senaste 30 dagarna har**
**- Du känt "oro", sveda eller smärta i magen?**

☐ 1 Aldrig
☐ 2 Någon enstaka gång
☐ 3 Några gånger i veckan
☐ 4 En eller flera gånger per dag
197

**8. Hur ofta under de senaste 30 dagarna har**
**- Du haft huvudvärk?**

☐ 1 Aldrig
☐ 2 Någon enstaka gång
☐ 3 Några gånger i veckan
☐ 4 En eller flera gånger per dag
198

**9. Hur ofta under de senaste 30 dagarna har**
**- Du känt Dig spänd i musklerna (t. ex. rynkar pannan, drar upp axlarna, biter ihop tänderna)?**

☐ 1 Aldrig
☐ 2 Någon enstaka gång
☐ 3 Några gånger i veckan
☐ 4 En eller flera gånger per dag
199

**10. Har Du haft känning av följande besvär under senaste tiden (sista halvåret)**
**- Svårighet att somna?**

☐ 1 Aldrig
☐ 2 Någon eller några gånger per år
☐ 3 Någon eller några gånger i månaden
☐ 4 Flera gånger i veckan
☐ 5 Varje dag
200

**11. Har Du haft känning av följande besvär under senaste tiden (sista halvåret)**
**- Upprepade uppvaknanden med svårigheter att somna om?**

☐ 1 Aldrig
☐ 2 Någon eller några gånger per år
☐ 3 Någon eller några gånger i månaden
☐ 4 Flera gånger i veckan
☐ 5 Varje dag
201

**12. Har Du haft känning av följande besvär under senaste tiden (sista halvåret)**
**- Ej utsövd vid uppvaknandet?**

☐ 1 Aldrig
☐ 2 Någon eller några gånger per år
☐ 3 Någon eller några gånger i månaden
☐ 4 Flera gånger i veckan
☐ 5 Varje dag
202

**13. Har Du haft känning av följande besvär under senaste tiden (sista halvåret)**
**- Trött/sömnig under arbetstid/skolarbete eller fritid?**

☐ 1 Aldrig
☐ 2 Någon eller några gånger per år
☐ 3 Någon eller några gånger i månaden
☐ 4 Flera gånger i veckan
☐ 5 Varje dag
203

Vibit, arbetsmiljö, utkast 1

**14. Har Du haft känning av följande besvär under senaste tiden (sista halvåret)**
**- Hösnuva eller annan allergi?**

☐ 1 Aldrig
☐ 2 Någon eller några gånger per år
☐ 3 Någon eller några gånger i månaden
☐ 4 Flera gånger i veckan
☐ 5 Varje dag

204

**15. Har Du av Din läkare fått någon av följande diagnoser?**

| | | Nej (1) | Ja (2) |
|---|---|---|---|
| 205 | Astma | ☐ | ☐ |
| 206 | Diabetes | ☐ | ☐ |
| 207 | Migrän | ☐ | ☐ |
| 208 | Högt blodtryck | ☐ | ☐ |

## Uppföljning

**Vilket år är Du född?**

208 År 19 ☐☐

**Kön?**

☐ 1 Man
☐ 2 Kvinna

209

**Får vi återkomma till Dig och ställa fler frågor i hälsoundersökningar?**

☐ 1 Ja
☐ 2 Nej

210

**Din hemadress:**

.....
namn

.....
personnummer

.....
gatuadress

.....
postnummer & postadress

**Din hemtelefon:** .....

**Din mobiltelefon:** .....