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ORIGINAL ARTICLE

# Grading of sensorineural disturbances according to a modified Stockholm workshop scale using self-reports and QST

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**Abstract**

*Objective* The objective of the study was to apply, on a group of vibration exposed individuals, a proposed modification of the Stockholm Workshop scale for grading of sensorineural disorders by using self-reports and data from objective testing and to compare grading obtained through the two approaches.

*Methods* The study group consisted of 126 young persons with different individual levels of hand-transmitted vibration exposures. Effect measurements included a self-administered questionnaire and vibrotactile perception measurements and Purdue Pegboard testing. For grading using self reports three specific questions, believed to be good markers for complaints of intermittent numbness, sensory deficiency, and reduced performance in fine motor tasks, was picked out from the questionnaire. Results from vibrotactile perception and Purdue Pegboard testing were used for grading based on quantitative sensory testing. The sensorineural grading obtained by the two methods was then compared.

*Results* The outcome showed that about 60% of all individuals within the study group are graded equally by the two methods for grading. The frequency of individuals graded at advanced SN stages were however higher when using QST, predominantly due to more positive cases for the Purdue pegboard test compared with the corresponding outcome from the self reports.

*Conclusion* The proposed modification of the grading scale reduces the in-built progressiveness and allows different combinations of sensorineural symptoms. The two grading methods seem to be somewhat correlated, something which may be considered as encouraging and promising for those who prefer to use, or must use one of the methods for grading. The proposed model for grading using self-reports should, however, be considered more as a conceptual idea for how this may be done. The models should 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 drawn.

**Keywords** Arm · Hand · Exposure · Sensory neuropathy · Occupational health · Vibration

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## 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 (e.g. Anonymous 1995; Brammer et al. 1987; Gemne et al. 1995; Lundborg 1988). In order to grade the severity of the dysfunction the Stockholm Workshop scale for grading sensorineural disorders (Table 1) has been widely used (Brammer et al. 1987). 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.

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 symptomatological 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) (Anonymous 1995; Gemne et al. 1995). 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, thermotactile perception thresholds, two-point discrimination test, Purdue pegboard test for manual dexterity and, monofilaments. Different aspects of QST methodology, such as pros and cons in relation to hand–arm vibration neurological diagnosis is in detail discussed elsewhere (Lundström 2002). It can, however, be stated that QST is in general easy to perform, usually not associated with pain, and suitable for screening. QST is, however, known to be susceptible to the effects of multiple covariates and test methodologies. The sensitivity, specificity and reliability of different methods for QST vibration-induced sensory neuropathy are still very much unknown. Lack of normative values, standardization of methods and of a "gold standard" for sensorineural disorders is also a problem. In addition, QST demands equipment, some of which are quite sophisticated 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.

**Table 1** The Stockholm workshop scale for grading sensorineural disorders in vibration-exposed persons (Anonymous 1995)

| Stage[a] | Description |
|---|---|
| SN0 | Vibration-exposed but no attacks |
| SN1 | Intermittent numbness, with or without tingling |
| SN2 | Intermittent or persistent numbness, reduced sensory perception |
| SN3 | Intermittent or persistent numbness, reduced tactile discrimination and/or manipulative dexterity |

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

For all epidemiological investigations, which 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 (e.g. QST). For reasons mentioned earlier and on the basis of our experience a modified grading scale using self-reports has been outlined (Table 2). 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, the modified grading scale is now allowing the situation that symptoms of reduced manipulative dexterity and/or reduced sensory perception may be present without complaints of numbness.

## Objectives

The objectives of the present study are to apply, on a group of vibration exposed individuals, the proposed modification of the Stockholm Workshop scale for grading of sensorineural disorders by using self-reports and data from objective quantitative sensory testing and to compare grading obtained through the two approaches.

## Methods

### Subjects

From the enrolment lists of vocational schools programs (auto mechanic, construction, and restaurant) in northern and western Sweden 3,300 students who graduated in 2001–2003 were asked to answer a screening questionnaire.

**Table 2** Proposal for grading of sensorineural disorders in vibration-exposed persons using self-reports

| | Nocturnal numbness | Drop things easy | Difficulty with buttoning |
|---|---|---|---|
| SN0 | – | – | – |
| SN1 | + | – | – |
| | – | + | – |
| | – | – | + |
| SN2 | + | + | – |
| | + | – | + |
| | – | + | + |
| SN3 | + | + | + |

Responses came from 1,868 (57%) persons (1,561 men and 307 women), of these 1,029 persons were approved to participate in further research studies. They were given a baseline self-administered questionnaire developed within the VIBRISKS project (Lundström et al. 2004). 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 (e.g. vibrotactile perception thresholds, Purdue Pegboard testing). The final analysis included data for both hands of 126 persons, mean age (±SD) 21 years (±1.1 years). Sensorineural staging on two right hands could, however, not be conducted due to missing data. The final study group were on average exposed to an 8-h frequency weighted daily acceleration magnitude of about 1 $ms^{-2}{}_{r.m.s.}$ measured in accordance with ISO-standard 5349-1 (5349-1 2001).

## 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 dichotomized; "No" as "-" and "Insignificant" through "Rather much" as "+".

### *Grading using quantitative sensory testing*

Vibrotactile thresholds, aimed to address the component "Reduced sensory perception" in SN2 in the Stockholm workshop grading scale (Table 1), 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 and 125 Hz, i.e. four measurements for each hand. Vibrotactile perception threshold data for digit 2 and 5 is shown in Table 3. The thresholds for digit 5 are significantly higher for all test points (Paired *t* test, $P < 0.02$–0.000). The individual test result for each measurement point and test frequency was considered as unusual if the recorded threshold was higher than the study group's mean + 1SD. The case definition for reduced sensory perception (+) was at least 2 unusual 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 1). 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 s fell below the study group's mean − 1SD (Table 3). The case definition for intermittent numbness (+) was same as for grading using self reports (see above).

The sensorineural grading for each individual was then conducted in accordance with Table 2.

## Results

Table 4 shows cross-tabulated frequencies of SN-stages as a result of the two models for sensorineural grading, as can be seen that about 58–60% of both hands are graded equally. Grading using QST does, however, result in a 3.1–3.7 times higher frequency of SN1 for the left and right hand, respectively, which is mostly due to higher frequency of Purdue pegboard cases compared to corresponding self-reported cases having difficulties with buttoning. This is also supported by the nonparametric statistics presented in Table 5 (Wilcoxon matched-pairs signed ranks test).

## Discussion

The outcome of this evaluation has showed that 58–60% of all individuals within the study group are graded equally by the two methods, using self-reports and QST. Furthermore,

**Table 3** Mean and standard deviations for vibrotactile perception and Purdue pegboard ($n = 126$)

| Vibrotactile perception threshold ($ms^{-2}$) | | | | Purdue pegboard (pins/30 s) | |
|---|---|---|---|---|---|
| Left hand | | Right hand | | Left hand | Right hand |
| 32 Hz | 125 Hz | 32 Hz | 125 Hz | 13.5 (±1.8) | 14.0 (±1.9) |
| Digit 2 | | | | | |
| 0.151 (±0.1) | 0.228 (±0.18) | 0.167 (±0.11) | 0.280 (±0.19) | | |
| Digit 5 | | | | | |
| 0.183 (±0.1) | 0.310 (±0.26) | 0.194 (±0.13) | 0.355 (±0.33) | | |

**Table 4** Crosstabulated frequencies of SN-stages graded using self reports or using quantitative sensory testing (QST)

| Using self report | | Using QST | | | | Total |
|---|---|---|---|---|---|---|
| | | SN0 | SN1 | SN2 | SN3 | |
| Left hand | SN0 | 64 (50.8%) | 26 (20.6%) | 6 (4.8%) | | 96 |
| | SN1 | 7 (5.5%) | 10 (7.9%) | 2 (1.6%) | | 19 |
| | SN2 | | 3 (2.4%) | 2 (1.6%) | 1 (0.8%) | 6 |
| | SN3 | | 2 (1.6%) | 3 (2.4%) | | 5 |
| | Total | 71 | 41 | 13 | 1 | 126 |
| Right hand | SN0 | 65 (52.4%) | 25 (20.1%) | 5 (4.0%) | | 95 |
| | SN1 | 8 (6.4%) | 6 (4.8%) | 3 (2.4%) | 1 (0.8%) | 18 |
| | SN2 | 2 (1.6%) | 3 (2.4%) | 1 (0.8%) | | 6 |
| | SN3 | | 2 (1.6%) | 3 (2.4%) | | 5 |
| | Total | 75 | 36 | 12 | 1 | 124 |

**Table 5** Wilcoxon matched-pairs signed ranks test with respect to SN-stages graded using quantitative sensory testing (QST) and self reports

| $SN_{QST}$–$SN_{self\ report}$ | | | | | | |
|---|---|---|---|---|---|---|
| Hand | Ranks | *N* | Mean rank | Sum of ranks | *Z* (based on negative ranks) | Asymp. significance (two-tailed) |
| Left | Negative | 15 | 24.83 | 372.5 | −2.766 | 0.006 |
| | Positive | 35 | 25.79 | 902.5 | | |
| | Ties | 76 | | | | |
| | Total | 126 | | | | |
| Right | Negative | 18 | 27.28 | 491.0 | −1.933 | 0.053 |
| | Positive | 34 | 26.09 | 887.0 | | |
| | Ties | 72 | | | | |
| | Total | 124 | | | | |

it could be observed that the frequency of individuals graded at advanced SN stages were higher when using QST. The cause for this discrepancy is predominantly due to more positive cases for the Purdue pegboard test compared with the corresponding outcome from the self reports. The outcome of the two grading methods seem, however, to be somewhat correlated, something which may be considered as encouraging and promising for those who prefer to use, or must use one of the methods for grading.

The present proposal for grading should, however, be considered more as a conceptual idea for how grading using self reports may be done. The concept has been tested on a cohort consisting of relatively young persons for whom all necessary data for grading was available. It should, however, be said that this test population is not optimal. For instance, the prevalence of sensorineural disturbances in various stages, and in particular at advanced stages, within the present study population is low to allow a serious test. The two grading 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.

Clear and justified case definitions for QST as well as self reports are of outermost importance when adapting this type of grading models. For this particular study it may have been possible to approve the correlation between the two grading methods by adjusting the used case definitions.

For QST there is a difficulty with the interpretation of test results. In research and clinical settings a person is considered as normal when QST indicate a result inside the range of 2SD from a normative value. This range covers about 94.5% of a healthy population assuming a Gaussian distribution of results. As mentioned earlier the prevalence of sensorineural disturbances was as expected quite low in our young study group. The above case definition (i.e. 2SD) was found to be too strict in this case. For QST results, the definition for a positive (+) case was, therefore, set to the mean + 1SD, covering about 80% of a healthy population. It is, however, worth bearing in mind that for a person with an inherent QST result in the upper end of the normative interval only a minor deterioration may cause the person to be classified as abnormal. In addition, there is also a risk that individuals showing hypersensitivity, which actually is a sign of disease, is wrongly classified as healthy cases (i.e. -). For an adequate and reliable interpretation of QST results it should be combined with a carefully conducted bedside physical examination (Nilsson 2002).

An important issue for QST is also how normative values have been collected and compiled. Since results from QST are dependent on test methodology it is in most cases suitable and maybe necessary to use an own set of normative values. In this study, the mean and standard deviation for the study group itself has been used for the evaluation. This means that the normative value, as well as the standard deviation, used in this study to some extent is affected by those who have deteriorated QST results. This may lead to an underestimation of positive QST cases when comparing with normative values for a healthy independent reference group. How much all this may have influenced the outcome is not assessed and thus not known. Since the study group is young and healthy it may be reasonable to assume a limited influence on the outcome.

Case definitions when using self reports is of course of equal importance. In this study, the four graded answers given in the three questions picked out from the self-administered questionnaire was dicotomized as a positive case when the reply was "Insignificant" through "Rather much". It would, however, been more logically to not include "Insignificant" in this category but the reason for doing so was the same as for categorizing individual QST results, namely to few positive cases for a meaningful test of the grading models.

As mentioned earlier, a grading of sensorineural disturbances in according with the current Stockholm Workshop scale involves difficulties in some cases due to the grading scale's progressiveness. This difficulty is avoided in the proposed modification of the sensorineural grading scale presented in this study which allows different combinations of symptoms. Another issue is if the grading must be based on objective findings via results from QST 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, e.g. 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 (e.g. long distances, large and wide spread study group, etc.). In this case, the possibility of conducting grading through self reports would be of great value.

## Conclusion

The aim with this study was to apply two models for sensorineural grading, one based on self reports and other based on quantitative sensory testing, on a slightly modified Stockholm Workshop scale. The proposed modification of the grading scale reduces the in-built progressiveness and allows different combinations of sensorineural symptoms. The outcome shows that about six out of ten individuals are graded equally by the two methods for grading. The result is thus encouraging for those who prefer to use, or must use one of the methods for grading. The present proposal for grading using self reports should at this stage be considered more as a conceptual idea for how grading using self reports may be done. The two grading models should 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.

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