COMBINATIONS OF EXPOSURE TO VIBRATION, NOISE AND ERGONOMIC STRESSORS IN THE SWEDISH WORK FORCE AFFECT MUSCULOSKELETAL HEALTH OUTCOMES

Mats Hagberg and Andreas Jonsson
Dept. of Occupational & Environmental Medicine, University of Gothenburg, 405 30 Gothenburg, Sweden

1. INTRODUCTION

Exposure to vibration both hand-arm vibration (HAV) and whole-body vibration (WBV) involves mechanical energy transferred to the human body. These mechanical oscillations also cause noise. Thus workers exposed to vibrations are also exposed to noise. Furthermore workers exposed to WBV and HAV are often simultaneously exposed to other ergonomic stressors, such as awkward postures and manual material handling (lifting) [1].

In a study of the Swedish workforce from a survey conducted in 1999, 2001 and 2003 by Statistics Sweden, we found that when the exposure factors lifting and frequent bending were added to a multivariate analysis, there was surprisingly a low magnitude of association between low back symptoms and whole body vibration exposure [2]. Interestingly, the relation between whole body vibration exposure and symptoms in the neck, shoulder/arm and hand had the same or higher magnitude of association even when the possible confounders were in the model. For the neck, low back and shoulder/arm there was an increase in prevalence ratio (as high as 5 times) when combined exposures of whole body vibration, lifting, frequent bending, twisted posture and noise were included in the analysis [2].

There are few studies of combination of exposure to noise and vibration on possible health effects such as musculoskeletal disorders and hearing problems. It has been proposed that sympathetic vasoconstriction causes hearing impairment as an explanation to the finding of an association between hearing problems and Raynaud's disease [3]. If so, there would also be a possibility of an association between ergonomic stressor and hearing problems since it has been hypothesized that chronic muscle pain conditions are associated an increased sympathetic activity.

1.1. Aim

To study the combinations of exposure to vibration, noise and ergonomic stressors in the Swedish workforce, and the effect on self-reported health outcomes such as musculoskeletal symptoms and hearing problems.

2. METHODS

The occurrence of exposure to noise in the working environment was considered for surveys conducted in 1997, 1999, 2005, 2007 and 2009 by Statistics Sweden (SCB), by order of the National Board of Occupational Safety and Health. Exposure to noise in these surveys is defined as "Exposed at least 1/4 of the time to noise so that you cannot speak in a normal tone". All together, the sample for these surveys is over 44,000 employed persons.

This cross-sectional working environmental study is based on material from a survey conducted in 1999 by Statistics Sweden (SCB), by order of the National Board of Occupational Safety and Health. Data concerning the working environment was collected by phone interview and questionnaire. The response rate for the phone interview was 88% (12,546 employed persons) and for questionnaire there was a 69% response rate (9,798 employed persons). These responders were the study population for the analytical study of risk factors for musculoskeletal and hearing disorders. For individual questions the level of non-response was between 1% and 3%.

2.1. Vibration and Noise Exposure

The definition of exposure to whole body vibration (WBV), hand transmitted vibration (HAV) and noise was based on three different questions, "Are you at work exposed to vibrations that make your whole body vibrate (e.g. tractor, truck or other working machines)?" "Are you at work exposed to vibration from hand held machines (e.g. compressed air machines, jigsaw or similar)?" "Are you at work exposed to noise that is so high that you cannot talk in a normal tone?" All questions had the same six response alternatives, "Almost all the time", "About 3/4 of the time", "At least half the time", "About 1/4 of the time", "Slightly (maybe 1/10 of the time)", and "Not at all". Exposure cutoff was set to "At least half the time". The regions for musculoskeletal symptoms considered were low back, neck, shoulder/arm and hand.

2.2. Statistics

Descriptive statistics were constructed for symptoms, vibration exposure, noise exposure, other risk factors, and age stratified for gender. The effect measure used for all analyses was prevalence ratios (PR) with 95% confidence intervals (CI). A proportional hazard model with time set to one was used to assess PR. All analyses were adjusted for gender and age. The relation between symptoms and noise exposure was examined. A multivariate model assessing the relation between risk factors, exposure and symptoms was analyzed. Risk factors included in the multivariate model were significant in a univariate model assessing the relation between factors and symptoms. The relationship between

variables was considered with Spearman's rank correlation to avoid multicollinearity, and variables with a correlation >0.7 were not included in the same model. Risk combination factors were analyzed one at a time, adjusted for gender and age. Statistical significance was set to $p \leq 0.05$ or equivalent, and the 95% CI for PR not to include one. All analysis was performed with SAS 9.1. The multivariate analysis models used PROC PHREG.

3. RESULTS

In the sample of 12,546 persons representing the Swedish workforce, exposure to noise and ergonomic stressors such as lifting and bending was frequent among both men and women, whereas vibration exposure, both HAV and WBV, was frequent among men (around 6 percent) but less than one percent among women (Table 1).

Table 1. Descriptive statistics for symptoms and exposure stratified for gender. Data are given as numbers and percent (%). n=12,546.

Variable	Men	Women
Neck	640 (15%)	1417 (30%)
Low back	546 (13%)	867 (19%)
Shoulder/arm	635 (15%)	1265 (28%)
Hand	299 (7%)	631 (14%)
Hearing problems	128 (2%)	121 (2%)
Lifting (15-25 kg)	1277 (29%)	942 (20%)
Lifting (>25 kg)	773 (18%)	462 (10%)
Frequent bending	1528 (35%)	1878 (39%)
Twisted posture	635 (15%)	757 (16%)
Whole body vibration (WBV)	271 (6%)	35 (1%)
Hand-arm vibration (HAV)	295 (7%)	47 (1%)
Noise	834 (19%)	483 (10%)
WBV and Noise	189 (4%)	23 (0.5%)
WBV and no Noise	81 (2%)	12 (0.3%)
WBV and HAV	91 (2%)	9 (0.2%)
WBV and no HAV	175 (4%)	25 (0.5%)
HAV and Noise	211 (5%)	20 (0.4%)
HAV and no Noise	82 (2%)	27 (0.6%)

In a multivariate analysis, hand-arm vibration had a significant prevalence ratio of 1.5 for hand pain, even when controlling for whole body vibration, noise, frequent bending, lifting and twisted posture (Table 2).

The combination of ergonomic stressors gave a prevalence ratio of 14.2 (95% CI 8.6-23.6) for hand pain.

Table 2. Multivariate analysis of musculoskeletal symptoms and hearing symptoms in relation to ergonomic stressors and individual factors. Data are given as prevalence ratios (PR) with 95% confidence interval (CI).

Variables	Hand symptoms		
	PR	95% CI	
Gender (women/men)	2. 3	2.0	2.7
Age	1.03	1.03	1.04
Whole body vibration	1.4	1.0	1.8
Lifting (15-25 kg)	1.4	1.2	1.6
Frequent bending	2.3	2.0	2.7
Twisted posture	1.3	1.1	1.6
Noise	1.6	1.3	1.9
Hand-arm vibration	1.5	1.1	1.9

4. DISCUSSION AND CONCLUSIONS

This study clearly describes the complex nature of physical exposure relation with hand symptoms. We need to consider multiple exposures when preventing musculoskeletal disorders. The importance of considering ergonomic confounders when evaluating the health effects of HAV exposure is fundamental.

REFERENCES

1. Palmer, K. T., Griffin, M. J., Syddall, H. E., Pannett, B., Cooper, C., and Coggon, D. (2003). "The relative importance of whole body vibration and occupational lifting as risk factors for low-back pain," Occup. Environ. Med., **60**(10), 715-21.

2. Hagberg, M., Burstrom, L., Ekman, A., and Vilhelmsson, R. (2006). "The association between whole body vibration exposure and musculoskeletal disorders in the Swedish work force is confounded by lifting and posture," J. Sound Vib., **298**(3), 492-498.

3. Palmer, K. T., Griffin, M. J., Syddall, H. E., Pannett, B., Cooper, C. and Coggon, D. (2002). "Raynaud's phenomenon, vibration induced white finger, and difficulties in hearing," Occup. Environ. Med., **59**(9), 640-2.

4. Sjors, A., Larsson, B., Dahlman, J., Falkmer, T., and Gerdle, B. (2009). "Physiological responses to low-force work and psychosocial stress in women with chronic trapezius myalgia," BMC Musculoskeletal Disorders **10**, 63.

ACKNOWLEDGEMENTS

This study was supported by the Swedish Council for Working Life and Social Research.