# Is real-time monitoring effective as a control measure to prevent Hand Arm Vibration Syndrome

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## Abstract

The most recent advances in sensor technologies have given rise to a proliferation of applications using frequently gathered data to continuously improve operational performance. The authors seek to illustrate whether such an approach is valid in the control of exposure to harmful vibrations from power tools. The authors investigate the range of exposure possible when closely monitoring a single task and analyse a large set of monitoring data from a wearable devise for possible under-assessment of risk. The investigators conclude that over reliance on generic risk assessments may place certain individual tool users at greater risk. Modern monitoring devices can help identify at risk individuals and assess the effectiveness of control measures

### *Key words:*

Hand-transmitted vibration, monitoring, wearable sensors

## Introduction

Employers who expose their workforce to hazardous vibration from mechanised tools need to develop an understanding of the magnitude of vibration and time of exposure to vibration that their workers have experienced often while using multiple tools within a day. ISO 5349-2 [1] was developed as an international standard to define how the time and magnitude of vibration exposure should be combined to quantify the risk to the individual. The standard requires the placement of accelerometers on the tool surface while in use and instrumentation of a nature which requires a skilled technician to interpret the gathered data. In essence the standard does not facilitate the economic collection of data across a range of tool users on a routine basis.

Step 1: the authors carried out a blind assessment of real-use exposure levels for a group of tool operators when assigned with the same task as part of a time in motion study to quantify the range of exposure across a group of experienced operators. The operators were deployed with an instruction to work share to control the expected exposure level.

Step 2: given the wide range of individual exposure found in the first exercise the authors then analysed a large data set of exposure monitoring data collected by a wearable sensor to assess how effective the access to real-time data was in controlling the operator's exposure. The wearable sensor was configured to collect data simultaneously based on a fixed vibration magnitude assumed for the tool and a real-time vibration magnitude detected during the tool's use by the sensor. This configuration allowed an assessment of how readily the wearable sensor assessed the risk relative to the assumed fixed vibration magnitude. Also with the fixed vibration magnitude acting as the control measure instructing operators to take action, to what extent would real time monitoring capture higher risk than expected from the assumption of traditional risk assessments of an assumed fixed vibration magnitude for each tool.

## Consideration of range from a single task

To illustrate the variability from tasks a detailed risk assessment exercise was carried out on the work of 15 tool operators in multimen teams, each excavating a one meter squared hole within the same grade of road surface. Each operator used the same tool type for which the employer had determined a vibration magnitude of 12 $m/s^2$. Note this was well in excess of the tool vibration data declared by the manufacturer of 4.2$m/s^2$. A mix of site teams were used per excavation which consisted of between two and four man teams.

**Results:** The range across the excavations was +/- 40% with an average to inform a task based risk assesment per excavation equating to an A(8) of 4.2$m/s^2$. The employer assessed that if work was evenly shared, a two man team would be exposed to an A(8) of 2.9$m/s^2$ and a three man team exposed to an A(8) of 2.4 $m/s^2$ per excavation. A task based assessment will typically only account for an average exposure risk per task, not the actual exposure of individual operators. The individual exposure range was determined by plotting in Figure 1 the maximum exposure monitored for each individual in the exercise for just one excavation, with an A(8) exposure ranging from 1.7 to 4.8 m/s$^2$.

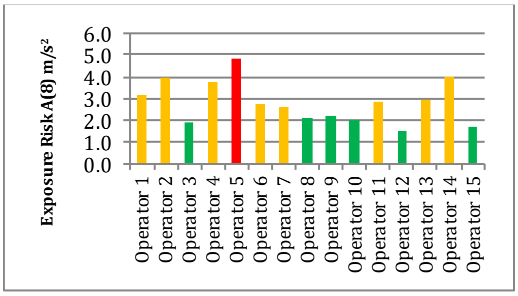


Figure 1: Maximum HAV risk exposure for each individual for one excavation

**Risk Levels from a controlled environment of wearable monitors**

Given the wide range of exposure for real-tool use the authors believe there is a need for real-time monitoring of exposure to HAV to be considered as a control measure and source of data for HAV management. The arguments for not doing so concern either fears that a wearable senor such as one worn on the wrist can adequately assess the risk and whether the access to real time exposure encourages employers to work individuals to the limit. In the second part of this paper the authors examine whether a wrist worn wearable sensor is likely to under estimate exposure risk by analysing a large data set where the wearable devise collected exposure data simultaneously based on trigger time with both a fixed vibration magnitude for each tool used and a real-use vibration magnitude determined by the sensor. The feedback of information to the tool operator was based on the fixed vibration magnitude. The authors analysed data from approximately 246,500 days of operator HAV exposure data, accrued from over 400 organisations across a range of industry sectors in a 9-month period between September 2017 and May 2018 involving 13,831 individuals with a devise collecting data as described in the introduction.

The fixed vibration magnitude for each tool used was selected by the employer to be that suitable for a risk assessment. The suitability of the wearable sensor to determine a vibration magnitude suitable for a risk assessment is assessed in a technical report by the IOM [2] while Maeda et al [3] examined the strength of correlation of the wearable's vibration determination and the human response to vibration. To assess the wearable's real-time assessment of risk relative to the employers assumed vibration magnitude, the data was sorted to identify the individuals with the greatest risk within the population set. As summarised in table 1 the individuals with greatest exposure had a materially higher risk when assessed by the wearable.

Table 1: Average daily exposure within population groups sorted by the most at risk individuals

| % of overall population incurring stated % of overall exposure | Wearable assessment | | | |
|---|---|---|---|---|
| | # of operators | % of population | Population mean A(8) m/s$^2$ based on fixed vibration | Population mean A(8) m/s$^2$ based on wearable |
| Top 20% | 97 | 0.7% | 3.0 | 6.2 |
| 20 - 40% | 319 | 2.3% | 2.8 | 3.6 |
| 40 - 60% | 694 | 5.0% | 2.1 | 2.6 |
| 60 - 80% | 1,506 | 10.9% | 1.7 | 2.0 |
| End 20% | 11,215 | 81.1% | 1.5 | 1.5 |

**Discussion**

Within a group of workers there will be a large variation of HAV exposure out with that expected from generic risk assessments as illustrated from both studies. When monitoring technologies are deployed human behaviour responds to the device alerts and provides a natural control as can be seen from table 1 where for even the highest risk group of individuals the average daily exposure is below the ELV as determined using the fixed vibration magnitude. However, the wearable devices assessment is generally higher and variance to the fixed vibration assessment is greatest where average risk of the group is highest. This is most likely caused by the fixed assessment being based on manufacturer's declared vibration levels. A stronger assessment of the effectiveness of monitoring would be to create a controlled experiment with monitoring with and without alerting.

**Conclusion**

A wearable devise can be effective in controlling exposure levels when an individual is alerted to their exposure levels. Monitoring data can be a useful source of information for informing tool selection, process controls and personnel skills.

**References**


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(3) Proceedings of 53thUKHRV, pp.11-24,2018