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Letter to the Editor

Frequency Weightings for Hand-Transmitted Vibration − Results of the Ottawa Workshop

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Introduction

In this collection of papers we have read about a range of research being applied to understanding the relationship between exposures to hand-transmitted vibration and injury to the hand and arm. These include laboratory studies designed to investigate specific human physiological and psychophysical responses or to determine biodynamic models for the hand and arm; animal surrogate studies to investigate damage mechanisms; and workplace studies seeking to demonstrate empirical relationships between exposures and apparent effects on the worker populations.

The presentation of these papers, and the related workshop held in Ottawa in 2011, were brought about by a desire to improve the assessment of health risks from hand-arm vibration exposures. Currently these risks are evaluated in accordance with International Standard, ISO 5349–1:2001[1)], and key to the application of this Standard is the frequency weighting W_h as defined in ISO 8041:2005[2)].

Within the International Standards and research communities there has been for some time an acknowledgement that W_h did not represent risk well for some machine types, and a desire to develop a frequency weighting that was more effective, particularly for vascular injuries. For this reason the ISO working group responsible for the ISO 5349 Standards proposed some candidate weightings for consideration in October 2008. The Ottawa frequency weightings workshop, held as part of the 12th International Conference on Hand-Arm Vibration, and this special edition of Industrial Health represent the best information currently available to inform this debate.

Consequences of change

Changes to ISO 5349–1:2001 cannot be made lightly. We must be mindful of the fact that this Standard underpins many other Standards, is referenced in guidance on the control of risk from hand-arm vibration and, in some jurisdictions, is incorporated into workplace health and safety law. Further, we have to recognise that ISO 5349 has provided an effective standard for determining how to minimise health risks from workplace vibration exposures and has been successfully used as the basis for developing low-vibration machinery.

In considering alternatives to the W_h frequency weighting we have to balance a tension between the academic requirement for rigor and the practical requirement to protect people at risk. It is unlikely that a single, simple frequency weighting could be defined that is able to predict hand-arm vibration risk in all cases. As Griffin observes here in his paper: "It is more likely that the physiological and psychophysical responses to hand-transmitted vibration are varied, complex, and non-linear defying simple precise definition"[3)].

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Confounders

It is accepted that there are many confounding factors that will affect health risks from hand-arm vibration exposures: indeed ISO 5349–1, in its Annex D, provides a list of possible factors likely to influence the health effects of exposures.

Shock

One confounding factor that was raised passionately by some experts in the Ottawa 2011 workshop was that of shock vibration. A view was expressed in the workshop that the damage mechanism from shocks is different to that from continuous vibrations, which the ISO 5349 methodology and the W_h weighting may be overlooking. The review paper presented here by Krajnak *et al.* highlights evidence from rat-tail impact vibration models where rapid and severe tissue injury has been demonstrated, suggesting a "need for an ISO regulation that considers the contribution of vibration energy from high frequencies when assessing risk to workers using percussive tools" [4].

Coupling forces, posture and other ergonomic issues

Another confounding factor that was discussed in the Ottawa workshop concerned coupling forces. Push and grip forces are generally considered to be important factors in the way the hand and arm absorb vibration energy. Dong *et al.* in their paper presented here[5], observe that the coupling force affects the biodynamic models and, by implication the absorption of potentially damaging energy into the fingers, hand and arm. Measurement of coupling forces is difficult, and largely (but not entirely) restricted to laboratory measurement. The evaluation of coupling forces is now standardised by ISO 15230:2007[6], and hopefully will lead to increased confidence in the quality of coupling force measurement and a better understanding of the forces applied to hand-held machines.

Uncertainty and inconsistency of diagnosis and measurement

Workplace studies, like those reported here by Bovenzi[7], Brammer and Pitts[8], and Pitts *et al.*[9], depend on reliable and consistent diagnosis of hand-arm vibration injuries and reliable and consistent evaluation of workplace exposures. Fundamentally these both are dependent on accurate reporting by individual workers, as well as accurate measurement of power tool and machine vibration. We rely on workers to provide details of the signs and symptoms of injury that they experience, and often the time of their first occurrence. We also rely on workers to remember their histories of machine usage. All these important factors are subject to recall bias.

Support for Change

The key objective of the Ottawa 2011 workshop was to establish whether there was support in the international specialist community for a new frequency weighting for the vascular component of the hand-arm vibration syndrome. If there were support, this would provide the International Standards working group with a mandate for change. A secondary objective was to establish what form that change might take.

The hope of the organisers was perhaps to confirm a positive mood for change, perhaps in the form of a supplementary weighting to the existing W_h. The actual meeting outcome was less clear: the delegates' discussion reflected a concern that there are many confounding factors needing to be investigated, and consequently that there is insufficient evidence to support a modified frequency weighting at the present time. One group did suggest that there is merit in measuring a flat weighting with a bandwidth to be discussed, but another group observed that without further information on dose-response relationships, it is unlikely that any new weighting would find broad application.

The workshop agreed two resolutions:

Resolution 1: While recognising there are limitations with the current frequency weighting, this workshop does not believe that there is sufficient evidence to propose an alternative to the current ISO frequency weighting.

Resolution 2: Possible alternate frequency weightings should be considered for specific purposes and described in technical reports.

Next Steps

The work on this topic has now returned to the ISO working group. The group will give consideration to developing a supplementary weighting, within a technical report. Such a weighting could be used along-side (not as a replacement for) W_h. It might be that the scope of such a weighting is restricted to specific injury types (e.g. vascular injury). The objective of such developments would be to provide an alternative focus for future research.

With this collection of papers and reports from the Ottawa 2011 frequency weightings workshop we have attempted to provide up-to-date information from authoritative sources, to serve as food-for-thought, to stimulate

discussion and work amongst those with an interest in improving the assessment of the health risk of hand-arm vibration, and ultimately to reduce workplace injury.

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