Supporting occupational health and wellbeing professionals

v. 2 September 2023

HAND ARM VIBRATION SYNDROME (HAVS) and WHOLE BODY VIBRATION (WBV)

CONTENTS

TABLES

1. INTRODUCTION

1. The following has been produced by members of the Society of Occupational Medicine HAVS Special Interest Group as a resource to assist those involved in the diagnosis and management of workers potentially exposed to whole body vibration (WBV).

2. This guide does not aim to be a comprehensive overview of WBV, nor does it seek to replace existing guidelines or formal education. Rather, it is a practical summary intended to provide background information and assist practitioners who may be asked to advise about the subject.

3. The guide has been prepared by members of a working group set up by the Society of Occupational Medicine (SOM) but does not necessarily represent the views of any individual member of the group, and the working group makes no assumption that its recommendations represent the views of all the members of the Society.

4. While the guide is presented in good faith, it is the responsibility of the reader to ensure that their approach to matters relating to WBV accords with best current practice, and legal requirements, and the SOM will accept no responsibility resulting from the failure of any reader to do so.

5. The Special Interest Group (SIG) welcomes any comments or suggestions regarding this publication. The SOM will assist members by directing specific enquiries about WBV, hand-arm vibration syndrome (HAVS) or carpal tunnel syndrome (CTS) to an appropriate member of the Group.

6. The Society of Occupational Medicine would like to thank Dr Roger Cooke and Dr Ian Lawson, who gave their time and expertise in developing this guide, and members of the SOM HAVS Special Interest Group for support, comments and suggestions.

7. According to modern practice standards, clinical activity is expected to be reliable and based on the current best evidence. In medicine this is usually based on peer-reviewed, published scientific literature. Evidence-based medicine provides a framework for clinical decision-making processes and integrates the evidence with clinical experience and individualised subject factors. However, the evidence may be limited in its relevance and applicability, as is often the case in WBV.

8. The aim of this document is to provide general advice on WBV and combine a review of the best available evidence for management with current expert practice. Accordingly, the document aims to summarise the evidence currently available relating to WBV in a concise and easily readable form, and provides consensus views of the group in respect of that evidence.

9. The document has been developed primarily for occupational health practitioners who are engaged with managing and supporting workers with exposure to WBV. It can also be accessed by other health professionals or technicians who may find the content useful. The intention is not to provide prescriptive rules for individual cases but to assist with the management of WBV in the workplace. It should be read in conjunction with SOM documents on HAVS and CTS, and Health and Safety Executive (HSE) guidance L141.

2. KEY MESSAGES

1. Health effects of WBV are generally poorly defined, although there is evidence that indicates an effect on the lumbar spine and associated tissues.

2. It is important to distinguish between whole body vibration and local effects of regional vibration.

3. While risk assessment is required under the Control of Vibration at Work Regulations, there is insufficient data to relate measured exposure to WBV to the likelihood of an individual developing adverse health effects.

4. Cases of back pain in those exposed to WBV require a holistic assessment, to include consideration of other medical causes, as well as other workplace factors such as posture and ergonomics.

5. Routine health surveillance is not appropriate for WBV.

6. Monitoring for back pain can be undertaken as part of other general health monitoring.

7. A pragmatic approach is required in managing those with back pain apparently associated with WBV exposure, with consideration of all possible relevant factors.

8. While further evidence is required regarding the effect of WBV on pregnancy, some reports suggest a potential effect and a cautious approach appears to be appropriate when offering advice to employees.

3. WHOLE BODY VIBRATION (WBV)

Whole body vibration (WBV) refers to the generalised effects of exposure of the whole body to vibration. It is defined in HSE guidance INDG242 as "the generalised effects of exposure of the whole body to vibration, usually by sitting in a tractor or other vehicle, but also when an individual is standing on a vibrating platform". [1]

In 2000 it was estimated that 7.2 million men and 1.8 million women in the UK are exposed on a weekly basis to occupational WBV.[2] Another earlier study showed higher prevalences in farming, forestry and road transport, where 12% of men and 1% of women reported their job involved sitting or standing on a vibrating machine or vehicle.[3] It has also been estimated that 2.7% of the US workforce is exposed to WBV each day – which equates to 3.5 million workers.[4]

A review of relevant literature was published by the HSE in 2001, and referred to a 1931 paper by Reiher and Meister which stated that *"the deleterious effects of street and machine vibrations are known"*.[5] Potential sources of WBV are listed in HSE guidance ref INDG242 (Table 1), which also states that *"most people who drive road-going vehicles at work are not likely to experience high levels of whole-body vibration and so their employers are unlikely to have to take any action under these Regulations"*.

- **Off-road mobile machinery**
- **Agricultural vehicles or industrial trucks**
- **Drivers of other vehicles, particularly if they suffer from back pain**
- **Standing on a structure attached to a large, powerful, fixed machine which is impacting or vibrating**
- **FLTs driven over poor surfaces**

Table 1: *Examples of sources of whole body vibration.* *Ref: HSE INDG242*

4. MEASUREMENT OF WBV EXPOSURE

As for hand-transmitted vibration (HTV), WBV is measured in three axes using an accelerometer. It is expressed as an acceleration in units of metre/sec/sec or ms-2. In HTV, a root sum of squares of vibration in each of the three axes is used to calculate total vibration. However, the value used for calculating daily exposure to WBV – the daily A(8) – is the highest of the frequency-weighted measurements taken in each of the three axes. The HSE have a WBV exposure calculator to assist this process. (See https://www.hse.gov.uk/vibration/wbv/calculator.htm)

Unfortunately, the lack of epidemiological evidence means that measurement of WBV exposure levels and calculation of daily A(8) exposure does not allow prediction of adverse health effects, or estimation of risks of such effects in an exposed individual.

Measurement of the vibration dose value (VDV) is believed to give a better indication of vibration including shocks, and is a cumulative value based on the cumulative dose but is not used for the purposes of risk assessment in the UK. Irrespective of which exposure index is adopted, WBV measurements should be carried out in accordance with ISO 2631-1.

5. MECHANISMS OF DAMAGE FROM WHOLE BODY VIBRATION

There are two potential routes via which exposure to WBV may have a pathological effect – either directly via transmission of vibrational energy into the whole body or via resonance. It is also likely that most WBV is a combination of 'regular' vibration and impact forces, so any relationship between such exposure and putative health effects will be complex and difficult to define. It is possible that repeated muscular contractions occur around these resonant frequencies, and contribute to symptoms of pain, aching and fatigue.

Resonance is the frequency at which vibration is amplified rather than attenuated. Whole body resonance has been estimated by a number of authors – see Table 2. In line with such estimates, Grether found that discomfort from WBV peaked at about 5 Hz – the level at which there is greatest resonance of the large organs of the body. Individual organs within the body have differing resonances – see Table 3.

- **Standing** 8–10 Hz (Ji et al. 1995)
- **Standing** 9–16 Hz Independent of mass height and BMI (Randall et al. 1997)
- **Seated** 5 Hz with second mode about 10 Hz
- **Standing** 5.5 Hz with second band 9–14 Hz
- **Sitting** 4–6 Hz (absorbed power) (Fairley & Griffin 1998)

Table 2: *Examples of estimated frequency of whole body resonance*

Organs	Resonance Frequencies (Hz)
Head	20 to 40
Spinal column	8
Chest wall	60
Abdominal	4 to 8
Shoulders	4 to 8
Lungs	4 to 8
Hands & arms	20 to 70
Ocular globe	60 to 90
Maxilla	100 to 200

Table 3: *After Duarte 2006* [7]

6. POTENTIAL HEALTH EFFECTS OF WHOLE BODY VIBRATION

Back pain, sciatica and lumbar disc degeneration are the most commonly discussed health effects of WBV, although effects due to individual organ resonance remain a possibility. ISO 2631 (2018) Annex B[8] states that WBV health effects include an increased risk to the lower lumbar spine and connected nervous system of the segments affected. Other factors such as bending forward or twisting are likely to increase any adverse health effects.

Health effects of WBV on the cervical spine and autonomic and gastrointestinal systems are not supported by evidence.[9, 10, 11] In his Handbook of Human Vibration, Professor M J Griffin describes the effects of WBV[12], and divides those effects into five groups: degraded comfort, interference with activities, impaired health, perception of low-magnitude vibration and motion sickness. A summary of possible health effects of WBV is given in Table 4 below.

Acute effects	Chronic effects
Postural control – <1 Hz or > 15 Hz	Spinal column – back pain, sciatica, lumbar disc degeneration
Vestibular dysfunction	Gastrointestinal
Altered stomach motility	Autonomic
Muscle fatigue	Neurological
General fatigue	Cardiovascular
Headache	Reproductive
Cognitive function, concentration and drowsiness	Renal
Discomfort, nausea, motion sickness, mal de debarquement	

Table 4: *Possible health effects of WBV*

7. WBV, THE SPINE AND BACK PAIN

There is an extremely wide range of factors with potential to influence the development of back pain in an individual (see Table 5), making the role of WBV difficult to define, when considered in the context of constitutional factors, other underlying conditions and potential ergonomic influences. Nevertheless there is evidence that WBV does affect the lumbar spine in several ways,[14] including inflammatory and degenerative changes, reduced vertebral density, cartilaginous endplate tears and changes to the intervertebral discs. Some studies have shown a high rate of degenerative spinal changes – as demonstrated by X-ray, CT or MRI – although there is poor correlation between such changes and the nature and severity of symptoms reported, either generally or in respect of WBV.

An exposure threshold effect has yet to be determined for WBV.

Where an individual presents with back pain potentially related to WBV exposure, workplace assessment should include all aspects of ergonomics as well as WBV assessment.

The aggravation of symptoms of back pain from exposure to WBV should be addressed pragmatically; in which circumstances, removal from such exposure may be appropriate.

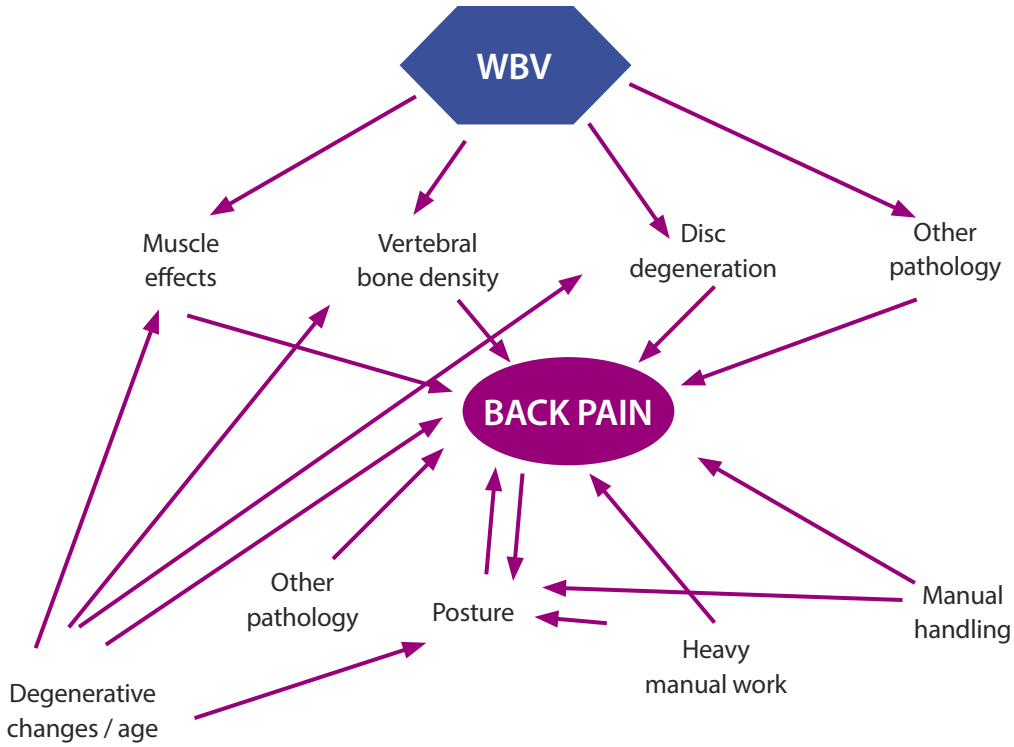

Table 5: *Potential contributors to back pain (Cooke, 2022)*

8. WBV AND PREGNANCY

In 1993 a review by Seidel concluded that 'increased risks of abortions, menstrual disturbances, and abnormalities of positions can be assumed to be associated with long term exposures to WBV'.[15]

Animal studies have demonstrated effects that could explain an effect of WBV on pregnancy. For example there is evidence that vibrations can be transmitted to the foetus; one study identified the resonant frequency of sheep uterus as between 6 and 18 Hz.[16] Nakemura et al[17] found that uterine blood flow was decreased in pregnant rats 75-90 minutes after exposure to vibration at 10m/s2 and 8Hz, although the relevance of this is unclear given that this is significantly higher than any current occupational exposure limit. Progesterone and prostaglandin E2 were also reduced, with the latter providing a potential explanation for the decreased uterine blood flow.

Vibration has been reported as an occupational risk factor for nuisance and for complications of pregnancy, such as premature birth and low child birth weight.[18] In 2018 Kromka-Szydek et al reported subjective responses to WBV in public transport or cars[19], noting that the frequency of vibration was typically 5-6.3 Hz, compared with abdominal organ resonant frequencies of 4.5 – 10Hz. While acknowledging the subjectivity of their findings these authors reported that travelling by car produced digestive disorders and increased foetal activity, while tram riding was associated with digestive disorders and headaches.

In 2007, Croteau et al[20] reported a significant increase in preterm delivery for mothers exposed to demanding posture for at least three hours per day, occupational whole-body vibration at the start of the pregnancy (OR 1.8, 95% CI 1.1-2.76), and high job strain combined with low or moderate social support. There was a similar association between these factors and very pre-term delivery (i.e. less than 34 weeks gestation). In this study information was collected by telephone after the childbirth, including self-reported occupational conditions, such as whole-body vibration at the start of and during the pregnancy. The authors acknowledged the possibility of recall bias. In addition the determination of vibration exposure was binary (yes/no) with no validation of the reported exposure, or analysis relating pregnancy outcome to estimated level of daily exposure. However their findings accorded with previous work by Mamelle et al in 1984, who reported weak epidemiological evidence (OR 1.7 95%CI 1.0-2.2) of prematurity being associated with "work on industrial machine" which might involve vibration 21, and that of Haelterman, E. et al in 2007 who concluded that WBV exposure was associated with preeclampsia, but non-significantly, (OR 1.4, 95% CI 0.7-2.8).[22]

In 2021, Skröder et al. reported a retrospective nationwide cohort study considering the effect of occupational WBV during pregnancy and found an increased risk for pre-term birth among women who were exposed to WBV compared to women who were not exposed.[23] In this study exposure was estimated using data from a range of existing sources, with ranges of exposure being assigned to specific job (occupational) codes (0 m/sec2, 0.1-0.2 m/sec2 , 0.3 – 0.4 m/sec2 and 0.5 m/sec2 or greater). In addition, a group of occupations with exposure to mechanical shocks was identified. They found that exposure to WBV in the highest exposure group was associated with an increased risk of preeclampsia, gestational hypertension and gestational diabetes among full-time workers, compared with non-exposed women. They acknowledged that further research is needed.

Conclusion

In 2009, Joubert et al concluded that there was "unclear and weak evidence of adverse reproductive outcomes" associated with prolonged exposure to whole-body vibration, but that the possibility should not be ignored.[24] The paper by Skroder et al[23] appears to provide stronger evidence of such an effect of WBV, but while this research provides the best evidence to date, conclusions are limited by the difficulty in assessing individual exposure to WBV. Based on their findings, they suggest that women should not be exposed to WBV at or above the action limit value of 0.5m/s2 continuously through pregnancy. While – in their words – these results need further confirmation, a cautious approach appears appropriate when offering occupational health advice to employees.

9. REGIONAL / SEGMENTAL EFFECTS OF VIBRATION

When considering WBV, it is important to recognise the distinction between regional vibration (sometimes referred to as segmental) and general (whole body) vibration. This is particularly important when considering symptoms attributed to vibration exposure.

Regional effects of vibration are most commonly seen in the fingers and thumbs as HAVS, although it is plausible that regional vibration occurs elsewhere, such as in the toes or the feet, where those parts of the body are exposed to vibration. The two main effects of regional vibration exposure are vascular, causing Raynaud's phenomenon, and sensorineural, causing sensory symptoms of tingling and/or numbness as a result of damage to the nerve endings and associated fine nervous tissue in the fingertips. Raynaud's phenomenon is due to episodic vasospasm of the peripheral arteries – in the case of the hands or the feet, the digital arteries.

Tingling and/or numbness may occur as a normal response to regional vibration exposure due to sensorineural effects, but those symptoms may become more protracted, and eventually permanent, with abnormalities on clinical examination.

CTS may occur in association with use of handheld vibratory tools, although there is debate as to whether that is due to ergonomic and postural effects or the vibration exposure itself. Where CTS occurs, for whatever cause, symptoms may affect the digits, palm and lower part of the forearm.

10. VIBRATION AND THE FEET

If one accepts that an effect of regional vibration exposure to the feet would follow the same pathological course as hand-transmitted vibration (which is hypothesis, and not proven), then one might expect a similar process of development of symptoms in the feet exposed to vibration. However, the effect of localised vibration on the feet is poorly defined.

In 2010 it was noted that *"a condition analogous to HAVS might occur in the feet after lower extremity vibration exposure is biologically plausible, though not well studied"*.[25] In that case report there was no neurological abnormality of the feet. A later (2014) review referred to foot-transmitted vibration (FTV), being distinct from hand-transmitted vibration or whole body vibration.[26] The authors noted that *"little is known about the characteristics of occupational FTV or clinical implications with prolonged exposure"*, and that a clear dose response relationship has yet to be proven. That review cited only two published reports of "vibration white toes". In one of those there was a mild neurological deficit in the affected foot. The review concluded that *"study is required to … better characterize and control foot transmitted vibration"* and that *"epidemiological evidence is required to link (foot vibration) exposure with injury"*.

In summary, therefore, neurological effects of regional vibration exposure to the feet are poorly defined or reported, and while there is a plausible argument that such effects may occur, as they do in the fingers, that has not been confirmed by epidemiological or other studies.

Some authorities accept that vascular symptoms of Raynaud's phenomenon may occur in the feet following local exposure of the hands to vibration, i.e. without apparent local exposure of the feet.[27] There is a lack of clear evidence in epidemiology or a pathological basis for this, although a sympathetic reflex phenomenon is a putative explanation.[28] It is notable that both toes and fingers are affected in less than half of cases of primary/constitutional Raynaud's; one early study found that 42.6% had both fingers and toes involved and 1% the toes only.[29]

11. VIBROACCOUSTIC DISEASE

Vibroacoustic disease was first described in 1987, as a whole-body pathology associated with long-term exposure to high-intensity, low-frequency noise exposure (20–500 Hz).[30] It is believed to reflect a range of pathologies such as cardiovascular changes including pericardial thickening, respiratory and gastrointestinal symptoms and psychological disorders including depression, irritability and aggression. The similarity between very low-frequency noise and vibration is such that there is a possibility of overlap with WBV.

12. LEGISLATION AND HSE GUIDANCE

The Control of Vibration at Work Regulations 2005 (CoVaW)[31] cover whole body vibration as well as hand-arm vibration. Regulation 2 of CoVaW defines whole body vibration as *"mechanical vibration, which is transmitted into the body, when seated or standing, through the supporting surface, during a work activity or as described in regulation 5(3)(f). Regulation 5(3)(f) extends the scope of WBV exposure to include any extension of exposure at the workplace to whole-body vibration beyond normal working hours, including exposure in rest facilities supervised by the employer"*.

The Health and Safety Executive (HSE) has published guidance on WBV, in HSE guidance document L141.[32] Paragraph 13 of that document states that *"the Vibration Regulations are designed to protect against risks to both health and safety from whole-body vibration, i.e. the risk of back pain in those exposed and situations where vibration may affect ability to handle controls or read indicators"*. L141 focuses on back pain associated with WBV exposure, and contains no specific reference to either vascular or neurological effects on the feet.

The Control of Vibration at Work Regulations (2005) define an exposure action value (EAV) and an exposure limit value (ELV) for WBV. For whole body vibration, the daily ELV – the maximum amount of exposure to which an employee may be exposed on any single day – is 1.15 m/s^2 A(8). The daily EAV is defined in paragraph 28 of L141 as that level *"above which you are required to take actions to reduce exposure"* – 0.5 m/s2 A(8). However, Regulation 6 includes an overriding duty to reduce exposure to as low a level as reasonably practicable.

13. RISK ASSESSMENT

HSE guidance document INDG242 states that *"you don't have to (measure employees' exposure) as long as you have done the broad risk assessment and take all the appropriate and reasonable control actions described in this leaflet"*. That reflects paragraph 41 of HSE guidance L141, which states that "*an assessment of exposure based on published information will normally be adequate … but you will need to be able to show … that the measures you have put in place will prevent the exposure limit value being exceeded. If you cannot do this using published data, you may have to arrange for measurements to be taken*".

It is noted that driving vehicles solely on-road is unlikely to result in the EAV being exceeded, unless the vehicles have poor suspension and are driven for most of a working day or shift, and that in most cases where the evidence suggests that exposure is unlikely to exceed the EAV, it will be sufficient to record that fact.

When undertaking a risk assessment for WBV, a number of factors should be considered in addition to the vibration, including:

1. adverse postural influences from
    a. poor design of controls such that the driver has to twist, bend, lean or stretch in order to operate the vehicle
    b. inadequate adjustment of seats and controls
    c. sitting in one position for prolonged periods
2. manual handling risks
3. other risks associated with access to and egress from a high or difficult access cab.

14. HEALTH SURVEILLANCE/ MONITORING

CoVaW Regulation 7(2) states that *"health surveillance, which shall be intended to prevent or diagnose any health effect linked with exposure to vibration, shall be appropriate where the exposure of the employee to vibration is such that*

a. *a link can be established between that exposure and an identifiable disease or adverse health effect*

b. *it is probable that the disease or effect may occur under the particular conditions of his work, and*

c. *there are valid techniques for detecting the disease or effect."*

It is evident that these criteria are not met in respect of WBV and back pain, and hence routine health surveillance is not appropriate for WBV. This is confirmed as the HSE position in paragraph 22 of guidance L141, which states that *"health surveillance (regulation 3(4)(a)) is not appropriate for WBV because it is considered that no methods currently exist for detecting changes in people's backs, which can reliably indicate the early onset of changes (which may cause low back pain) that are specifically related to workplace factors"*.

The HSE suggest that 'health monitoring' may be helpful, but this is not a legal requirement under the CoVaW Regulations, and reflects a holistic approach to back pain, using an annual checklist for employees at risk. This might reasonably be included as part of a driver's assessment or a 'safety critical worker' health review. A sample questionnaire is included in L141 (see Appendix A).

There is likely to be a value in pre-placement assessment of those with existing back pain, in which case all the ergonomic and manual handling issues should be considered as well as possible effects of WBV. In addition, early reporting of back pain symptoms, with assessment and treatment should be encouraged.

15. POSITIVE EFFECTS OF WHOLE BODY VIBRATION

Whole body vibration therapy is being suggested as having health benefits including improvement of bone density in post-menopausal women,[33] increased levels of growth hormone and testosterone,[34] improved walking performance after stroke and with OA knee[35] and control of type 2 diabetes.[36]

However, while these reports provide further evidence that WBV has a physiological/pathological effect on the body, extrapolation of this into workplace effects has yet to be considered. In addition the concept of 'work-hardening' is probably not appropriate for the *"complex, seated, jolt/vibration environment"* found in WBV exposure.[37]

APPENDIX A
HEALTH QUESTIONNAIRE AS RECOMMENDED IN HSE L141

	YES	NO
Any changes in duties/hours since last questionnaire?		
Recent experience		
Is there **currently** any movement or activity that causes you pain in your back?		
Have you suffered any back/neck/shoulder pain **in the last 12 months?**		

Please describe the severity of the pain experienced:

No pain **Pain as bad as it could be**

0	1	2	3	4	5	6	7	8	9	10

Note: if severity above 5 indicated, refer on for further advice.
*However, if rank less than 5, but for three consecutive assessments, then refer for further advice.**

Have you had to take any medication to deal with the pain experienced?	*	
Have you had to seek medical advice regarding this pain?	*	
Has this back/neck/shoulder pain resulted in time off from work?	*	
Have you had any accidents or injury to the back in the last two years?	*	

Action / advice

Referral for further advice?

Other advice provided?

Note: where answers occur in the boxes marked with an asterisk (*), the HSE recommends that further advice should be sought from an occupational health professional or GP.

REFERENCES

1. **HSE Guidance IND(G) 242. 2005. ISBN 0 7176 6119 9.**
2. Palmer KT, Griffin MJ, Bendall H, Pannett B, Coggon D.
Prevalence and pattern of occupational exposure to whole body vibration in Great Britain: findings from a national survey.
Occup Environ Med. 2000; 57(4): 229–36.
3. Jones JR, Hodgson JT, Osman J.
Self-reported working conditions in 1995: Results from a household survey.
HSE Books 1997. ISBN 0 7176 1449 2.
4. Tak S, Calvert GM.
The estimated national burden of physical ergonomic hazards among US workers.
Am J Ind Med. 2010; 54(5): 395–404.
5. Stayner RM.
Whole body vibration and shock: A literature review.
HSE Contract research report 333/2001 2001. Her Majesty's Stationery Office. ISBN 0 7176 2004 2.
6. Grether, WF.
Vibration and Human Performance.
Human Factors 1974; 13(3): 203–216.
7. Duarte MLM, de Brito Pereira M.
Vision influence on whole body human vibration comfort levels.
Shock and Vibration 13 2006; 13; 367–377.
8. **ISO 2631-5 (2018). Annex B.**
9. Palmer KT, Bovenzi M.
Rheumatic effects of vibration at work [In special issue: Occupation and Musculoskeletal Disorders].
Best Practice & Research Clinical Rheumatology 2015; 29(3): 424–439.
10. Bovenzi M.
Health effects of mechanical vibration.
G Ital Med Lav Ergon. 2005; 27(1): 58–64.
11. Seidel H, Heide R.
Long-term effects of whole-body vibration: a critical survey of the literature.
Int Arch Occup Environ Health 1986; 58(1): 1–26.
12. Griffin MJ
Handbook of Human Vibration.
2000. Academic Press.
13. Kjellberg A, Wikstrom B-O.
Acute effects of whole body vibration.
Scan J Environ Health 1987; 13; 243–246.
14. Bovenzi M, Palmer K.
Whole Body vibration. In: Baxter PJ, Aw T-C, Cockcroft A, et al, editors. **Hunter's Diseases of Occupations.**
10th ed. 2010. Hodder.

REFERENCES

15. Seidel, H.
Selected Health Risks Caused by Long-Term, Whole-Body Vibration.
American Journal of Industrial Medicine, 1993; 23, 589-604.

16. Peters, A. et al.
Resonance of the pregnant sheep uterus.
Journal of Low Frequency Noise, Vibration, and Active Control, 1992;11, 1-6.

17. Nakamura, H. et al.
Uterine circulatory dysfunction induced by whole-body vibration and its endocrine pathogenesis in the pregnant rat.
European Journal of Applied Physiology and Occupational Physiology, 1996; 72, 292-296.

18. Makowiec-Dabrowska T., Radwan- Wodarczyk W, Koszada-Wodarczyk W, Siedlecka J Wilcynski Y
The influence of chemical and physical factors in the work environment on the amount of risk for abnormal pregnancy outcome.
Med. Pr., 1997, 48, 239–59.

19. Kromka-Szydek M, Diechciowski Z, Tyrpin P
Preliminary assessment of vibration impacts generated by the public transport systems on pregnant women based on subjective reactions
Acta of Bioengineering and Biomechanics. Vol. 20, No. 1, 2018 DOI: 10.5277/ABB-00974-2017-03

20. Croteau, A, Marcoux, S. & Brisson, C. (2007).
Work Activity in Pregnancy, Preventive Measures, and the Risk of Preterm Delivery.
American Journal of Epidemiology, 166, 951-965.

21. Mamelle, N., Laumon, & Lazar, P.
Prematurity and occupational activity during pregnancy.
American Journal of Epidemiology, 1984; 119, 309-322.

22. Haelterman, E. et al.
Population-based study on occupational risk factors for preeclampsia and gestational hypertension.
Scandinavian Journal of Work Environment and Health, 2007; 33, 304-317.

23. Skröder H, Pettersson H, Norlén F, et al.
Occupational exposure to whole body vibrations and birth outcomes – A nationwide cohort study of Swedish women.
Sci. Total Environ. 2021;751. doi:10.1016/j.scitotenv.2020.141476

24. Joubert, D.M
Professional Driving and Adverse Reproductive Outcomes: The Evidence to Date and Research Challenges.
The Open Occupational Health & Safety Journal, 2009; 1, 1-6.

25. Thompson A, House R, Krajnik K, Eger T.
Vibration white foot: a case report.
Occup Med. 2010; (60)7: 572–574.

REFERENCES

26. Eger T, Thompson A, Leduc M, et al.
Vibration induced white-feet: overview and field study of vibration exposure and reported symptoms in workers.
Work 2014; 47(1): 101–110. doi:10.3233/WOR-131692.

27. **HSE Guidance to Control of Vibration at Work Regulations L140 (2019).**
Her Majesty's Stationery Office. ISBN 978 0 7176 6565 5.

28. Sakakibara H, Yamada S.
Vibration syndrome and autonomic nervous system.
Cent Eur J Public Health 1995; 3 Suppl: 11-4.

29. Gifford RW, Hines EA.
Raynaud's Disease among Women and Girls.
Circulation 1957 VVI; 1012–1021.

30. Alves-Pereira M, Castelo Branco.
NAA Vibroacoustic disease: Biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signalling.
Progress in Biophysics and Molecular Biology 2007; 93(1–3): 256–279.

31. **Control of Vibration at Work Regulations 2005.**

32. **HSE Guidance to Control of Vibration at Work Regulations L141 (2005).**
Her Majesty's Stationery Office. ISBN 978 0 7176 6126 8.

33. Marín-Cascales E, Alcaraz PE, Ramos-Campo DJ, Martinez-Rodriguez A, Chung LH, Rubio-Arias JÁ.
Whole-body vibration training and bone health in postmenopausal women: A systematic review and meta-analysis.
Medicine (Baltimore) 2018; 97(34): e11918.

34. Weber-Rajek M, Mieszkowski J, Niespodziński B, Ciechanowska K.
Whole-body vibration exercise in postmenopausal osteoporosis.
Prz Menopauzalny 2015; 14(1): 41–7.

35. Fischer M, Vialleron T, Laffaye G, et al.
Long-Term Effects of Whole-Body Vibration on Human Gait: A Systematic Review and Meta-Analysis.
Front Neurol. 2019; 10:627. doi:10.3389.

36. Robinson CC, Barreto RP, Sbruzzi G, Plentz RD.
The effects of whole body vibration in patients with type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials.
Braz J Phys Ther. 2016; 20(1): 4–14. doi:10.1590.

37. Wasserman DE, Wilder DG, Pope MH, Magnusson M, Aleksiev AR, Wasserman JF.
Whole-body vibration exposure and occupational work-hardening.
J Occup Environ Med. 1997; 39(5): 403–7.

Supporting occupational health and wellbeing professionals