International Journal of Occupational Safety and Ergonomics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tose20

Introducing a new design of digital tool to increase vibration risk assessments: challenges with education-based interventions

Hans Pettersson, Pål Graff, Louise Fornander, Jessica Westerlund, Bodil Björ & Fredrik Sjödin

INTERNATIONAL JOURNAL OF OCCUPATIONAL SAFETY AND ERGONOMICS (JOSE)
https://doi.org/10.1080/10803548.2021.1928389

Introducing a new design of digital tool to increase vibration risk assessments: challenges with education-based interventions

Hans Pettersson [a], Pål Graff [b], Louise Fornander [c], Jessica Westerlund [c], Bodil Björ [a] and Fredrik Sjödin [d]

[a]Department of Public Health and Clinical Medicine, Umea University, Sweden; [b]Department of Work Environment Chemistry, National Institute of Occupational Health, Norway; [c]Faculty of Medicine and Health, Örebro University, Sweden; [d]Department of Psychology, Umeå University, Sweden

ABSTRACT

Objectives. This study aimed to investigate whether introducing a digital risk assessment tool, the Swedish National Vibration Database, would increase the number of risk assessments on hand–arm and whole-body vibration. Employer and safety representatives from companies where vibration exposure is common were invited. *Methods.* Of the 2953 invited companies, 1916 were selected for educational intervention and the remaining 1037 companies served as a control group with no intervention. For the educational intervention, participating companies were further divided into two groups (group A, $n = 26$; group B, $n = 47$) that both received information regarding risk assessment, but group B was also informed about the digital tool. Both groups answered a questionnaire on risk assessment before the intervention and at the follow-up, 6 months later; the control group received the same questionnaire but no education (group C, $n = 22$). *Results.* Of the invited companies, only 2% chose to participate and 7% at follow-up. Seventy-eight percent of the participants had made some kind of risk assessment of vibration at follow-up. *Conclusion.* Due to the low participation rate among invited companies, this study is not able to draw any conclusions on whether the digital tool can be used to increase the number of risk assessments.

KEYWORDS
vibration; intervention; digital tool; risk assessment; questionnaire

1. Introduction

Tools and machinery, which generate vibrations, are known to cause injuries to the hands, arms or lower back. Hand–arm vibration (HAV) from hand-held tools and machinery (i.e., grinder, chipping hammer, sabre saw, chain saw) increases the risk for hand–arm vibration syndrome (HAVS) with vascular or neurological injuries in the hand and digits as well as musculoskeletal syndromes [1,2]. Many workers who suffer from such injuries are forced to change occupation and may experience social and leisure restrictions [3]. As implied, whole-body vibrations (WBVs) affect the whole body and often originate from use of vehicles or larger machinery (i.e., excavator, forklift, wheel loader, truck), and in turn can lead to lower back pain (LBP) and sciatica [4]. AFA Insurance [5], the Swedish organization that insures the majority of Swedish employees, states that the most common approved cause of work-related diseases, among men, are related to vibration exposure (33%). Thus, risk prevention and training efforts for hazardous exposures such as vibrations in the workplace are essential to decrease the risk of injuries from occupational exposure [6]. For companies within the European Union (EU) it is mandatory to perform risk assessments regarding HAV and WBV upon use of hand-held tools and machinery or vehicles as stated in the EU directive on vibration [7]. It is the responsibility of the employer to evaluate the risks from vibration exposures among employees at the company. The risk assessment consists of estimating the daily vibration exposure level, type and duration, information from medical checkups, information from manufacturers of the vibrating machines, other work environment settings that increase the risk and information on employees with earlier injuries in the fingers, arms, hands or back. As part of the risk assessment, an expert can evaluate the vibration levels for individual workers, groups of workers or specific job activities. It is also important to compare the vibration levels for different models of the same machine types that the company may purchase.

A previous report, performed on vibration-associated risk assessment among companies in four regions of Sweden conducted by the Swedish Work Environment Authority, found that only half of the respondents had implemented the EU directive on vibration [8]. The report also stated that 18 and 52% of the respondents never or rarely, respectively, performed any vibration exposure risk assessment. This report suggested that the lack of risk assessments was due to lack of both knowledge of risks associated with vibrations as well as practical difficulties of measuring vibration exposure.

The use of various technical devices in modern society has become a natural part of the working environment [9]. In order to reduce the risk of work-related injuries, several technical solutions are available for assessing worker exposure to various physical health risks. For example, sound measurement applications for smartphones can give a good indication of whether the sound level poses a risk for hearing-related ill health [10,11]. Other digital tools have also been shown to have positive results for managing work-related stress and supporting the well-being of workers [12].

The EU directive states, as part of the risk assessment, that vibration levels can be assessed by direct measurement or by using earlier measurements [7]. One source of earlier measurements on vibration levels is the Swedish National Vibration Database (https://www.vibration.db.umu.se/app/) [13]. The database is a free online digital tool that gathers field

CONTACT Hans Pettersson hans.pettersson@umu.se

and Conformité Européenne (CE)-declared (laboratory setting) vibration levels on a number of hand-held vibrating machines and vehicles, and can be used to assess the vibration levels for risk assessments. It is available to the public in Swedish and English

In the present study, the Swedish National Vibration Database, used for risk assessment of HAV and WBV, has been redesigned to be more user-friendly and accessible and also available for use on multiple digital platforms. The aim was to increase the number of risk assessments being done regarding HAV and WBV in workplaces. The database has also been updated to include HAV and WBV measurements from more recent equipment models. Whether this will lead to an increase in the number of risk assessments being done is not certain, since there is a lack of studies investigating whether digital tools can increase the number of risk assessments on vibration.

The present study aims to investigate whether introducing a digital tool, in the form of the Swedish National Vibration Database, increases the number of risk assessments regarding vibration exposure in Sweden.

2. Method

The Swedish National Vibration Database consists of 1600 field measurements and 1800 CE-declared HAV measurements among 120 different types of hand-held vibrating machines and 560 WBV field measurements on 37 different types of vehicles, and is available in both Swedish and English. Users can search for HAV or WBV values and then specify the operating time for the worker for each machine or vehicle. The total exposure value is then automatically calculated. The information on vibration levels is used as part of a risk assessment on vibration. The user interface has been designed with two different search functions. The simple search allows the user to search for vibration values in different categories, i.e., a specific vehicle or machine. The vibration value in the selected category is presented as a median value, which is based on all added values in the last 20 years. The user can then add the selected machine or vehicle and enter the operating time per day. Several machines and vehicles can be added for an automatic calculation of the 8-h equivalent exposure level or total vibration (Figure 1). The advanced search is designed in a similar way, with the exception that the user can narrow the search regarding the model, power supply, weight, field measurement, CE values and year of measurement of a specific machine or vehicle type.

2.1. Study design

To investigate whether a new digital vibration risk assessment tool, available on multiple platforms such as smartphones and tablets, increases the number of risk assessments being performed in companies with workers exposed to hazardous vibration levels, this study included companies from six different branches with a majority of workers exposed to HAV and WBV. All companies invited to the present study were active primarily within either the service or maintenance of vehicles, gardening and forestry, manufacturing or earth moving for construction and roads. To increase the motivation of the different companies to participate, a reference group with employer organizations and unions from the included industries was linked to the project. The reference group was informed on the educational intervention and the development of a new design of the Swedish National Vibration Database and they were encouraged to find member companies that could be interested in participating in the study.

Each invited company was encouraged to send an employer or a representative for the employer as well as one safety

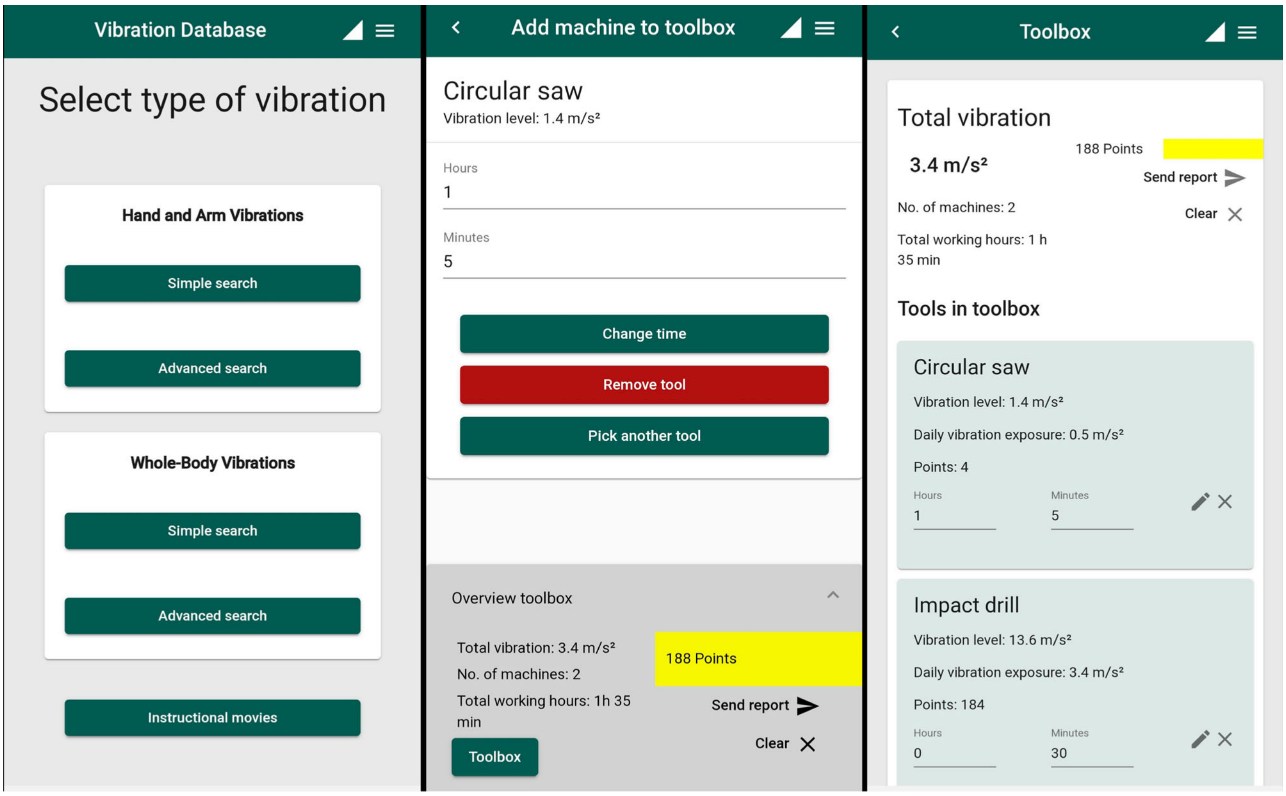

Figure 1. Database view of user-added machines. Summary of individual exposure for each machine and the total 8-h equivalent vibration value for all tools.

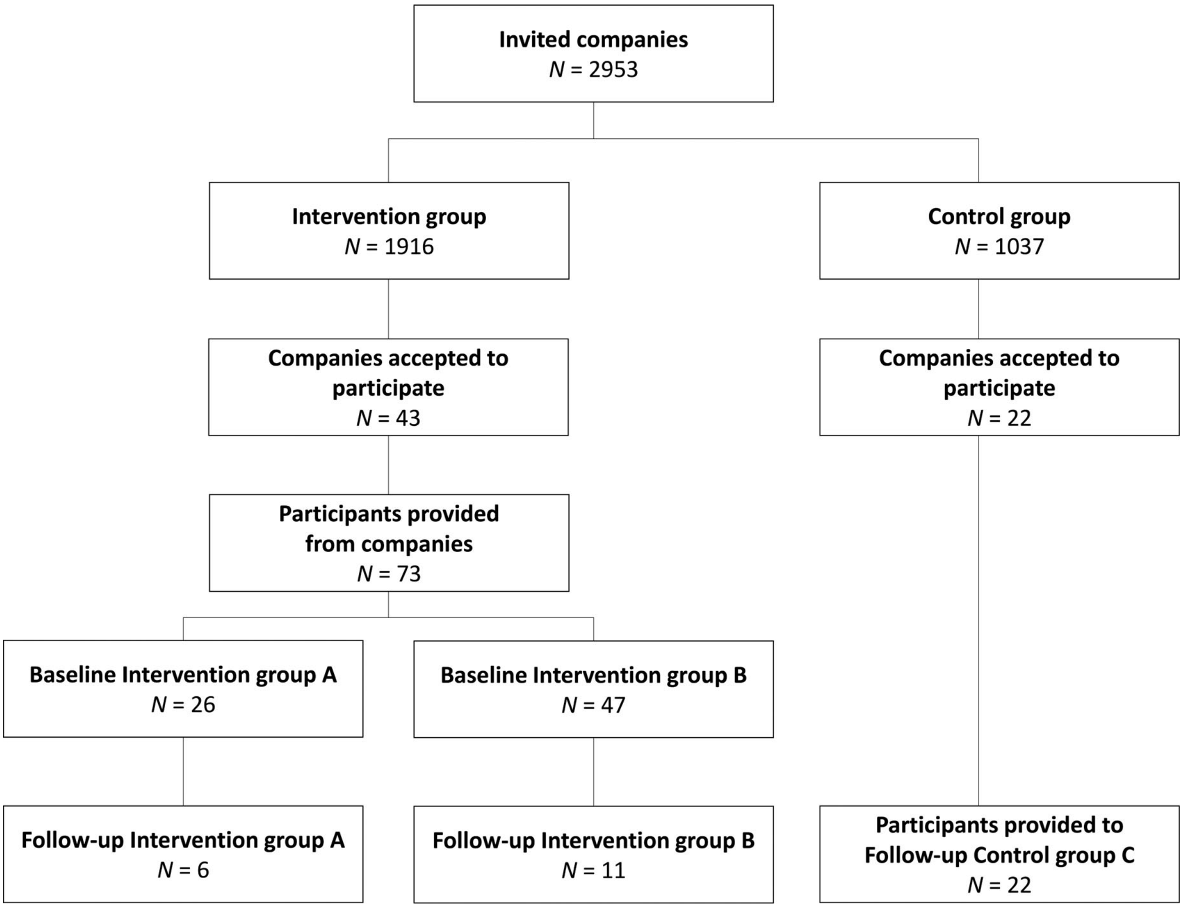

Figure 2. Flow chart of participants in the study and the distribution of the different intervention groups.

representative. All invited companies were further divided into two groups (group A and group B).

Group A at baseline (Figure 2) received, free of charge, educational information regarding risk assessment and vibration exposure by experts in legislation, vibration exposure and its effect on health. The information was given as a 1-h lecture, during normal work hours, on vascular, nerve injuries and musculoskeletal disease from exposure to hazardous HAV, lower back injuries from WBV, information on the EU directive and medical controls for employees exposed to vibrations, action and limit values for vibration, how a risk assessment is implemented by presenting how to assess vibration by measurement, CE-declared vibration levels and earlier measurement reports and databases.

Group B at baseline (Figure 2) received the same information as group A, but was also introduced to the Swedish National Vibration Database as a digital tool for assessing levels of vibration exposure. Groups A and B, were sent a link, by email, to a questionnaire investigating whether they had made any risk assessments in the last 12 months or not. They could also answer the questionnaire by paper and send their answer by mail.

The control group (group C; Figure 2), invited at the follow-up but not receiving any information, was used to compare whether groups A and B showed an increased number of risk assessments 6 months after the intervention.

Eight different regions, with varying size, across Sweden (Stockholm, Gothenburg, Malmö, Kiruna, Gällivare, Umeå, Örebro, Sundsvall) were included. Companies invited to the educational intervention were contacted 2 months prior to the educational intervention date, by either email, telephone or letter. In total, 2953 different companies were invited to participate. Out of these, 1916 companies were selected into group A or B according to region. This was done so that the information on the digital tool was not so easily spread among companies between regions. Group A consisted of companies from the regions of Gällivare, Örebro, Stockholm and Malmö, and group B from Kiruna, Umeå, Sundsvall and Gothenburg.

Forty-three companies participated with one or more representative in the educational intervention (see Figure 2). These 43 companies sent, in total, 73 participants to the educational intervention: 26 of 73 participants were assigned to group A and 47 participants were assigned to intervention group B.

At follow-up (Figure 2), the number of risk assessments in groups A and B was compared to the control group (group C). Group C was recruited from the same branches and regions as groups A and B. A total of 1037 companies in group C were invited to participate, and 22 companies accepted.

At follow-up, participants in groups A, B and C were sent a link, by email, to a follow-up questionnaire investigating whether they had made any risk assessments in the last 6 months or not.

After 2 weeks from first contact, at both baseline and follow-up, the companies received a reminder if they had not replied.

2.2. Questionnaire

At baseline, the questionnaire covered questions on the type of role at the company and whether a risk assessment had been made before participating in the study, and if so, what type of risk assessment: individual workers, groups of workers, work activities and purchase of vibrating machines. Risk assessment

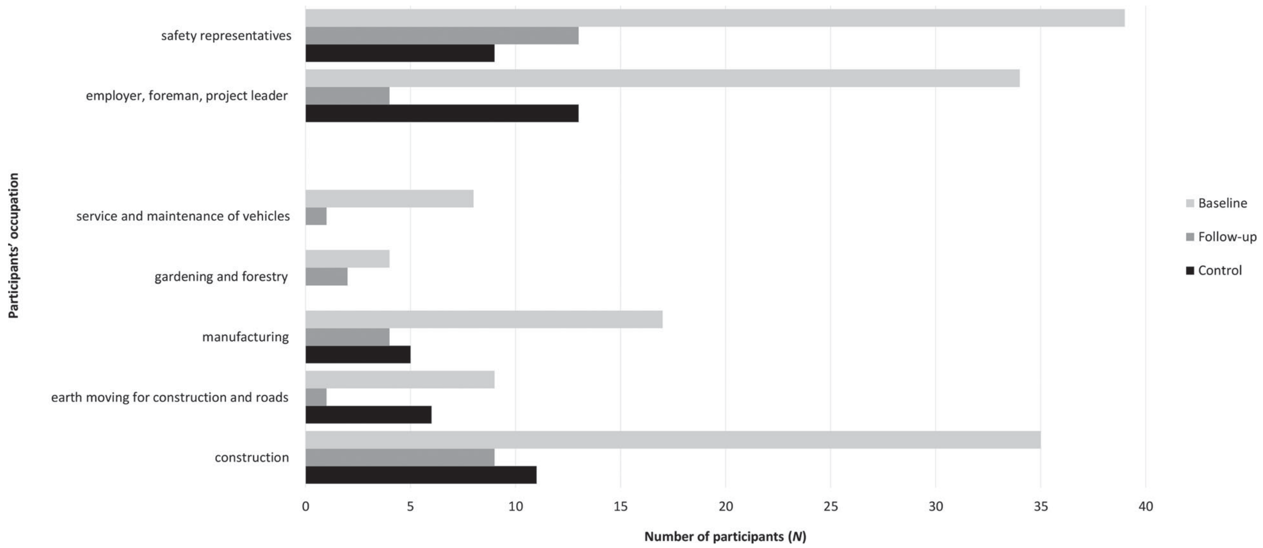

Figure 3. Number of participants separated by work title and industry.

on a single employee is made as an individual risk assessment. Risk assessment can also be done on a group of workers or specific work activities such as grinding metal, drilling in concrete, etc. The digital tool can also be used for risk assessment of future purchase of machines or vehicles. For each of the four risk assessments, there were questions on what tools they used to assess the exposure levels of HAV. The questions investigated whether they used measurements, CE values, earlier measurement and reports, and also whether they used the Swedish National Vibration Database and other tools.

At follow-up, groups A, B and C answered the same questions as at baseline and also questions regarding the user experience of the Swedish National Vibrations Database, e.g., whether a computer or mobile phone was used to access the database. Furthermore, the participants answered the system usability scale questionnaire [14,15]. The questionnaire constitutes 10 statements on the user experience, using a five-graded scale ranging from 'I don't agree' to 'I fully agree'. The 10 statements estimate how user-friendly the evaluated system is. Additionally, the questionnaire has two questions using a three-graded scale regarding the amount of information in the database (too much information, moderate amount of information, too little information) and how the information and text is understood (difficult to understand, moderate difficulty to understand, easy to understand).

3. Results

Of the 1916 invited companies at baseline and the 1037 invited for the control group, only 2% participated with at least one representative. At follow-up, 7% of the invited companies were represented. There were 18 companies with 26 participants in group A and 25 companies with 47 participants in group B at baseline. At follow-up, there were five companies and six participants in group A, nine companies and 11 participants in group B, and 22 companies and participants in group C.

The distribution of participants regarding the position of employer, foreman or project leader were 47% ($n = 34$) at baseline, 24% ($n = 4$) at follow-up and 57% ($n = 13$) among the control group. The majority of participants at baseline and follow-up and among the control group were from construction companies: 48% ($n = 35$), 53% ($n = 9$) and 48% ($n = 11$), respectively. At baseline, 60 men participated and 10 of them also participated at follow-up. Twelve men participated in the control group. Of the participants, 17% at baseline ($n = 13$), 41% ($n = 7$) at follow-up and 43% ($n = 9$) in the control group were females.

Most participants, both at baseline and follow-up and among the control group, stated that the company had made some kind of risk assessments of vibration (78%). A more detailed overview regarding the different types of risk assessment made by the participants is presented in Table 1. The control group made more risk assessments regarding purchase of new machines compared to intervention groups A and B. There were no risk assessment regarding groups of workers at follow-up in group A. The least used risk assessment was for individual workers at baseline (15–28%) and follow-up (0–17%). The most used risk assessment both at baseline (42–53%) and follow-up (27–50%) was assessments based on job activities.

At follow-up there were 14 participants who had used the digital tool: six participants in group A, four in group B and four in group C.

4. Discussion

The aim of this study was to investigate whether a digital tool with a new design, in the form of the Swedish National Vibration Database, increases the number of risk assessments regarding vibration exposure in Sweden. Among the companies that participated in the study, there was a reduction in the number of risk assessments of any type at the time of the follow-up. The observed differences at the follow-up for intervention group A were regarding assessment for job activities and for intervention group B were regarding groups of workers. Thus, the exposure assessments were mainly done for groups of workers and not for individual workers. However, it should be noted that the study suffered from a low participation rate (2% of the invited companies chose to participate), hindering any reliable analyses of whether the digital tool can be used as an instrument for increasing the number of risk assessments among companies with workers exposed to hazardous vibration levels.

Table 1. Type of risk assessment performed by participants at baseline (BL) or at follow-up (FU).

		Intervention group A			Intervention group B			Control group C		
Type of risk assessment		%	*n*	*N*	%	*n*	*N*	%	*n*	*N*
Individual worker	BL	15	4	26	28	13	47	–	–	–
	FU	17	1	6	0	0	11	5	1	22
Group of workers	BL	42	11	26	40	19	47	–	–	–
	FU	0	0	6	45	5	11	45	10	22
Job activities	BL	42	11	26	53	25	47	–	–	–
	FU	50	3	6	27	3	11	41	9	22
Purchase of machines	BL	35	9	26	44	17	47	–	–	–
	FU	17	1	6	9	1	11	50	11	22

Note: n = number of participants; N = total number of participants.

The use of digital tools for increasing risk awareness and preventive measures for different physical exposures has had some success before [16,17]. This includes an increased use of hearing protectors by computer-tailored feedback, hazardous occupational noise measurements via smartphones and different tools for stress reduction [10–12]. These studies support the idea that the Swedish National Vibration Database could be used as a tool to facilitate and increase the number of risk assessments.

Due to a lack of knowledge on hazardous HAV and WBV, an easy-to-use digital tool is warranted. A study of the Finnish construction and metal industry found that around 40% of the participants, consisting of occupational safety managers and representatives, had not considered including HAV in their risk assessment [18]. Occupational health services have suggested that the lack of risk assessment among Swedish companies is because companies with potential HAV exposure lack knowledge regarding exposure measurements [8].

It has been shown that workers suffering from HAVS often learned about the risks from vibration exposure from their co-workers after contracting HAVS [3]. Other studies have shown that the incitement to use anti-vibrating gloves increased if the workers were informed of the benefits of using them by co-workers [19]. This may indicate that co-workers may be an important channel for educational interventions.

Other intervention studies have, however, been more successful concerning participation compared to the present study. Sauni et al. [18] performed a 1-year information campaign to improve occupational safety managers' and representatives' knowledge and management of workers exposure to HAV and reached a participation rate of 51%. This may be due to the fact that they cooperated with several different unions and organizations in Finland. The present study did cooperate with employer organizations and union representatives for several industrial branches similar to Sauni et al. [18]. Another possible improvement, as shown by previous studies [16,17], would be the use of computer-based educational intervention to increase our participation rate.

A possible limiting factor for participation in the current study was that the educational intervention was performed during working hours, leading to loss of essential personnel and a reluctance to participate. It is possible that if we had given the option to have the intervention education during the evening, as in Kim et al. [20], the participation rate could have been increased. However, this would also inflict overtime costs for the companies that, in turn, could lower the incitement to participate in the education intervention.

There are no data on why companies did not participate since this study did not include ethical approval to contact non-attending companies. The functionality of the digital tool for vibration assessment and its usability can be discussed. However, the participating rate in the follow-up study was rather low for all participating intervention groups and the data do not suggest that the group being introduced to the digital tools had higher drop-out. We could therefore not assess the interest in the digital tool. Other reasons for the low participation include that risk assessment had already been performed or the participants already had knowledge of how to do risk assessments on HAV or WBV. Over 78% of the participants at baseline had already made some sort of risk assessment and they may therefore believe it is not necessary to perform additional risk assessment within the timespan of this study. The low participation rate could also be due to the fact that the invitation was sent to late to the companies and participation could not be properly planned within the organization. There could also be a lack of knowledge that the companies have hazardous HAV and WBV among workers or that they had no knowledge regarding the mandatory EU directive on vibrations.

5. Conclusions

Digital tools may be a promising way to help with risk assessments; however, due to the low participation rate in the current study, it is not possible to make reliable analyses on whether a digital tool can be used as an instrument for increasing the number of risk assessments among companies with workers exposed to hazardous vibration levels. There are several improvements that can be done to increase the participation rate.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by AFA Försäkring.

ORCID

Hans Pettersson http://orcid.org/0000-0001-7077-2389
Fredrik Sjödin http://orcid.org/0000-0002-1172-208X

References

[1] Bovenzi M, Prodi A, Mauro M. A longitudinal study of neck and upper limb musculoskeletal disorders and alternative measures of vibration

exposure. Int Arch Occup Environ Health. 2016 Aug;89(6):923–933. doi:10.1007/s00420-016-1131-9

[2] Nilsson T, Wahlstrom J, Burstrom L. Hand–arm vibration and the risk of vascular and neurological diseases – a systematic review and meta-analysis. PLoS One. 2017;12(7):e0180795. doi:10.1371/journal.pone.0180795

[3] Handford M, Lepine K, Boccia K, et al. Hand–arm vibration syndrome: workers' experience with functional impairment and disability. J Hand Ther. 2017 Oct–Dec;30(4):491–499. doi:10.1016/j.jht.2016.10.010

[4] Burstrom L, Nilsson T, Wahlstrom J. Whole-body vibration and the risk of low back pain and sciatica: a systematic review and meta-analysis. Int Arch Occ Env Heal. 2014 Aug 21; 88:403–418 doi:10.1007/s00420-014-0971-4

[5] AFA Insurance. Serious work injuries and long term sick leave. In: Allvarliga arbetsskador och långvarig sjukfrånvaro [Serious work injuries and long-term sick leave]. Stockholm: AFA Insurance; 2019. p. 1–133.

[6] Verma DK, Purdham JT, Roels HA. Translating evidence about occupational conditions into strategies for prevention. Occup Environ Med. 2002;59(3):205–214. doi:10.1136/oem.59.3.205

[7] European Union. Directive 2002/44/EC of the European Parliament and the Council of the European Union on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration). Off J Eur Communities. 2002;16:1–12.

[8] Gunnarsson L-G, Mölleby G, Porat A-M. Medicinsk kontroll vid användning av handhållna vibrerande verktyg – enkätstudie om tillämpningen av reglerna i företagshälsor och företag [Medical check-ups on the use of hand-held vibrating tools – survey study on the application of the rules in occupational health and companies]. Report 2011:13. In: Gunnarsson L-G, editor. Rapport. Stockholm: Swedish Work Authority; 2011. p. 1–14.

[9] Lange ML. The future of electronic aids to daily living. Am J Occup Ther. 2002;56(1):107–109. doi:10.5014/ajot.56.1.107

[10] Murphy E, King EA. Testing the accuracy of smartphones and sound level meter applications for measuring environmental noise. Appl Acoust. 2016;106:16–22. doi:10.1016/j.apacoust.2015.12.012

[11] Williams W, Zhou D, Stewart G, et al. Facilitating occupational noise management: the use of a smartphone app as a noise exposure, risk management tool. J Heal Saf Res Pract. 2017;9(1):6.

[12] Ryan C, Bergin M, Chalder T, et al. Web-based interventions for the management of stress in the workplace: focus, form, and efficacy. J Occup Health. 2017 May 25;59(3):215–236. doi:10.1539/joh.16-0227-RA

[13] Umeå University. Vibration database. Umeå: Umeå University; 2020 [cited 2020 March 26]. Available from: https://www.vibration.db.umu.se/app/

[14] Brooke J. SUS – a quick and dirty usability scale. In: PW Jordan BT, BA Weerdmeester, AL McClelland, editors. Usability evaluation in industry. London: Taylor and Francis; 1996. p. 189–194.

[15] Bangor A, Kortum P, Miller J. Determining what individual SUS scores mean: adding an adjective rating scale. J Usability Stud. 2009;4(3):114–123.

[16] Hong O, Ronis DL, Lusk SL, et al. Efficacy of a computer-based hearing test and tailored hearing protection intervention. Int J Behav Med. 2006;13(4):304–314. doi:10.1207/s15327558ijbm1304_5

[17] Lusk SL, Ronis DL, Kazanis AS, et al. Effectiveness of a tailored intervention to increase factory workers' use of hearing protection. Nurs Res. 2003;52(5):289–295. doi:10.1097/00006199-200309000-00003

[18] Sauni R, Toivio P, Esko T, et al. Effective information campaign for management of exposure to hand–arm vibration in the metal and construction industries. Int J Occup Safe Ergon. 2015;21(2):158–165. doi:10.1080/10803548.2015.1029287

[19] Leduc M, House R, Eger T, et al. Health and safety training and prevention of hand–arm vibration syndrome through education. Occup Ergon. 2016;13:45–51. doi:10.3233/OER-160238

[20] Kim J, Arrandale VH, Kudla I, et al. Educational intervention among farmers in a community health care setting. Occup Med (Lond). 2012;62(6):458–461. doi:10.1093/occmed/kqs129