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A STUDY OF THE PROACTIVE OCCUPATIONAL SAFETY AND HEALTH WORK IN A SWEDISH CONSTRUCTION COMPANY – THE EXAMPLE OF VIBRATION EXPOSURE

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Exposure to vibrations from tools and machines used in construction work can induce damages to the human body. One of the most frequent symptoms is the hand-arm vibration syndrome commonly known as white fingers. The proportions of the international workforce exposed to vibrations are high and dominating sectors are construction, agriculture, forestry, and transport. Particularly exposed construction occupational groups include machine operators and drivers of vehicles. In 2005, the Swedish Work Environment Authority introduced a new guideline on the topic of preventing vibration exposure risks (AFS 2005:15) based on the European union 2002/44/EC directive on workers' exposure to vibration. It includes raised demands on estimating vibration exposure, and clearly stated responsibilities and rights of employers and employees. However, in 2011 the Swedish Work Environment Authority's inspections showed that many employers belonging to sectors such as building and construction, transport, and mining industry did not have any satisfactory proactive risk management work concerning vibration exposure. This paper reports on a pilot study performed in a large Swedish construction company with the aim to yield more knowledge about factors affecting the implementation of the guidelines and to suggest actions for improvement. A total of 31 construction workers and supervisors were interviewed at nine construction sites in southern Sweden. Interview results demonstrated a lack of knowledge in estimating vibration exposure; the incorporation of the Work Environment Authority's directions had not been accomplished; driving forces for improving the proactive health and safety work and specifically vibration exposure management was weak on all organisational levels; important factors affecting the implementation of vibration exposure regulations are the psychosocial work environment at construction sites as well as company safety culture; a large proportion of the interviewed construction workers was judged to be at risk for developing vibration injuries if the exposure was not decreased; management, supervisory, and production levels need increased knowledge about vibration exposure and vibration injuries; and methods and tools for easy estimation of vibration exposure needs to be developed.

Keywords: hand-arm vibration syndrome, health and safety management, proactivity.

INTRODUCTION

Exposure to vibrations from tools and machines used in construction work can induce damages to the human body. Exposure to vibrations can lead to physical complaints in different ways. Vibrations are classified as either hand-arm vibrations or whole body vibrations. Exposure to these types of vibrations can pose substantial risks to worker's health (VIBRISKS 2007). When using handheld machines that vibrates oscillations

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are transmitted to arms and hands which can cause temporary or permanent injury (Hagberg 2002; Swedish Work Environment Authority 2005; Griffin et al. 2006). Injuries can arise on nerves, blood-vessels, joints, and muscles. One of the most frequent symptoms is the hand-arm vibration syndrome commonly known as white fingers. This syndrome generally involves whitened extremities, pain in arms and fingers and degradation in mobility and function when it comes to finer motor ability.

Hand-arm vibrations can also cause temporary musculoskeletal disorders (Refisch & Wålinder 2009; Griffin 1990). These disorders are difficult to derive from vibrations alone as they very probably are linked to other ergonomic risk factors.

A human being is exposed to whole body vibrations when standing on, sitting down on or leaning against a vibrating surface (Paschold 2008). When the human body is exposed to external vibrations these vibrations can cause resonance with the body's own vibrations leading to amplified oscillations in various body parts and organs.

The European Agency for Safety and Health at Work (2008) report that workers exposed to vibrations are overwhelmingly male and typically either drivers of mobile machines, operators of hand-tools, or people working in the vicinity of stationary machines. The proportion of the workforce exposed to vibration varies widely between European countries, from 14 % to 34 %, and is concentrated in the sectors of construction (63 %), manufacture and mining (44 %) and agriculture and fishing (38 %). Among Australian workers approximately 24% are exposed to vibration in their workplace and the industries with the highest likelihood of exposure to vibration are construction, agriculture, forestry and fishing as well as transport and storage (Safe Work Australia 2009). In the US it is estimated that 8-10 million people are regularly exposed to occupational vibration. In Sweden, the second most common occupational disease among males is vibration injuries (17 %). It is concentrated to the manufacturing and construction industries. The injuries affect all ages and as much as 30 % is below 45 years of age (Larsson, Normark, Paulsson & Åkerström 2013).

Particularly exposed occupational groups include machine operators and drivers of vehicles: groups that are present at most construction sites during the whole construction period. Vibrations can impair driver attention, cause drowsiness, as well as intrude on body movements. During heavy exposure the driver can experience physical and mental exhaustion as well as decreased performance. One of the most frequent vibration induced injury among construction workers are pain in the lower parts of the back (Paschold 2008).

In 2005, the Swedish Work Environment Authority introduced a new guideline on the topic of preventing vibration exposure risks (AFS 2005:15). The guideline is based on the European union 2002/44/EC directive on workers' exposure to vibration. The guideline includes raised demands on estimating vibration exposure, and clearly stated responsibilities and rights of employers and employees. Employers must plan, operate, and follow-up the work so that the risks for exposure for vibrations are minimized. Risk assessments should be conducted by the employer regularly, be revised and be documented. The regulation also sets action values and limit values for vibration exposure. When exposure action values are exceeded the employer is obliged to offer medical check-ups to employees and to review the workplace concerning vibration exposure. However, the employee may refrain from taking part in the medical check-ups. When exposure limit values are exceeded the employer have to take measures in order to reduce the exposure at the workplace.

In order to live up to the AFS 2005:15 the employer must estimate daily vibration exposure at the workplace and assess if it is unhealthy or not. The Swedish Work Environment Authority offers a specific method or tool which enables a simple estimation of daily vibration exposure. The method can be used both concerning hand-arm as well as whole body vibrations.

However, in 2011 the Swedish Work Environment Authority's inspections showed that seven out of ten employers did not have any satisfactory proactive risk management work concerning vibration exposure. The employers belonged to sectors such as building and construction, transport, and mining industry. Also, despite the new guidelines, the number of construction workers reporting occupational injuries due to exposure to vibrations has not decreased. Instead, the number of workers in Sweden exposed to whole body vibrations increased with 15 % from 1997 to 2009 (Karolinska Institutet 2009). The dominating industry is construction.

Aim of the paper

This paper reports on a pilot study performed in a major construction company in Sweden with the aim to yield more knowledge about factors affecting the implementation of the guidelines on vibration exposure. Through interviews at construction sites the aim was to get insight on the extent of vibration exposure, the awareness and knowledge about vibration injuries, conducted risk assessments and possibilities for improvements within the company regarding the occupational safety and health work and specifically concerning vibration exposure.

METHODS AND MATERIAL

Interviews were conducted in a major construction company in Sweden in order to get insight in the proactive risk management concerning work tasks were exposure for vibrations occur. In total, 10 site supervisors and 21 construction workers (including safety officers) were interviewed. All interviewees were men, between 22-61 years of age with an average age of 39 years (Table 1).

Table 1: Distribution of age groups among the 21 interviewed construction workers.

Age (years)	16-24	25-34	35-44	45-54	55-59	60-
	2	8	4	5		2

The interviews were conducted at nine construction sites of civil works in southern Sweden. The sites had one supervisor and at least two construction workers working there daily. The interviews were conducted during March - April 2012.

The interviews focused on: the existing routines at the work site when working with vibrating machines and equipment; the extent of vibration exposure: how many work hours per week with exposure? and is deliberate pauses taken during work with vibration exposure?; the interviewees awareness and knowledge about vibration exposure and consequences on the human body; the risks in daily work and if the risk assessment of vibration exposure and following measures reflected the demands from the Work Environment Authority; and possibilities for improvements within the company regarding the occupational safety and health work and specifically concerning vibration exposure.

RESULTS

Interviews were conducted at nine construction sites in southern Sweden and with a total of 10 site supervisors and 21 construction workers.

Estimation of vibration exposure at the construction sites

All 10 site supervisors answered that estimation of daily vibration exposures were not performed at the work sites. Even in those cases when vibrations had been noted as a risk in the project risk inventory no actual estimation of the extent of the exposures had been made. They were aware of the Work Environment Authority's regulations and knew where to search in order to find guidelines concerning the estimation of exposures. The site supervisors had not offered medical check-ups to employees in suspected cases of too high vibration exposure. In those cases when contacts concerning medical check-ups had been taken, these contacts had been made on the employees own initiative.

A tool for estimating daily vibration exposure is provided by the Work Environment Authority. The interviews showed that the site supervisors did not know about it, nor had they used alternative tools for estimating vibration exposure.

Vibrating tools and machines at the work sites

Several of the construction workers had used tools and machines with lower vibration levels than other equivalent machines. The same workers experienced that this equipment was much less effective compared to the other equipment. In several cases, after trying out the equipment with lower vibration levels and presenting complaints to the supervisory level, it had resulted in that the machine was sent back to the supplier in exchange of a more powerful and effective machine (which also had higher vibration levels). Several supervisors had similar experiences. When trying to take in machines recommended by the manufacturers or suppliers for their low vibration levels these machines were sent back due to complaints from the workforce. The interviewees' highlighted increased time pressures (which many experience in building projects today) resulting in the use of machines that are as efficient as possible. The risks for vibration injuries were not as known or evident. Also, the interviewer noted how little the machines had developed and changed in design the last five years.

Physical complaints among interviewees

Concerning the existence of physical complaints among interviewees three groups could be discerned.

Of the 21 construction workers four stated suffering from or having suffered from vibration injuries (19 %). Eleven of the 21 (52 %) stated having physical complaints judged to be in the area of vibration injuries, i.e. they either showed symptoms of vibration injuries even if they themselves did not judge them as vibration injuries, or they were at risk of developing vibration injuries in the future due to existing physical complaints.

Six of the 21 (29 %) interviewed construction workers had no physical complaints related to vibration injuries. Of these there were also individuals that did not know of anyone being affected by vibration injuries.

That majority of the interviewees that described short-term complaints from working with vibrating equipment, did not consider the complaints as injuries. To feel

discomfort in arms and hands several days after a completed work task or during a time period having the need for "shaking down the blood to the fingers" was taken with a shrug.

Perceived vibration exposure at the work sites

The interviewees were asked to try to estimate how many hours per working-week they were working with vibrating machines and tools. The average estimated exposure for the three groups is presented in Figure 1. The interviews clearly show that an increased vibration exposure was related to the group of employees with most physical complaints. Those who did not experience any complaints were much less exposed than those diagnosed with a vibration injury. Those diagnosed for vibration injuries were not exposed to vibrations as much as those experiencing physical complaints with suspected vibration symptoms. Interviewees with vibration injuries (white fingers, problems with fine motor abilities) worked overall about three hours per day with vibrating equipment, while those not suffering from any complaints worked two hours per day overall.

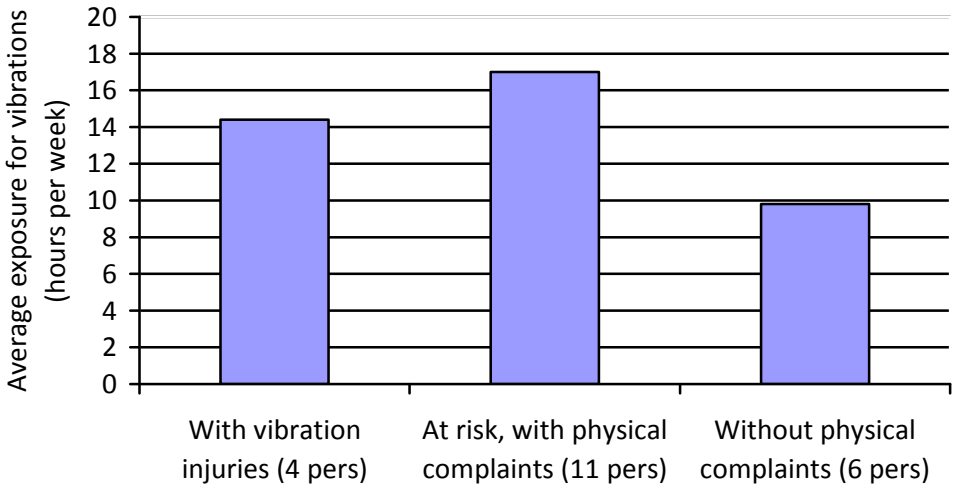

Figure 1: Average estimated exposure for vibrations (hours per week) for the three groups of construction workers (40 hour work-week).

The Work Environment Authority recommends work rotation as a measure to reduce exposure to vibrations as well as taking pauses during work with vibrating equipment. Interview results show that deliberate pauses were taken to a relatively small extent (Figure 2). More than 60 % of all interviewees did not take deliberate pauses while working with vibrating equipment. "You carry on until the work is finished, or until the body says stop. With the years you have learned to listen to your body".

Three of the four interviewees suffering from vibration injuries took deliberate pauses when using vibrating machines during their daily work. Those who took deliberate pauses to least extent belonged to the group being at risk for vibration injuries: less than one third of them took deliberate pauses. For individuals with no physical complaints, the number taking deliberate pauses were somewhat higher.

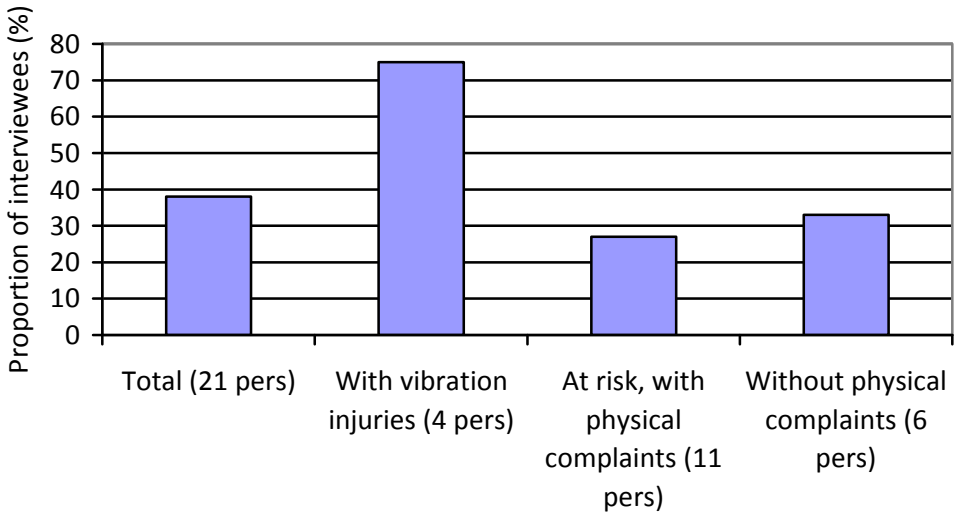

Figure 2: Proportion of the construction workers taking deliberate pauses while working with vibrating equipment, in total and for the three groups of construction workers.

Knowledge about vibration injuries

One part of the interview focused on how well site supervisors and construction workers knew about the consequences of vibration exposure. The symptoms that the interviewees knew best were white fingers and injuries on joints and muscles.

Nine of the 31 interviewees were judged to have inadequate knowledge about vibration injuries. They could come up with only one possible consequence of over exposure of vibrations; either white fingers or problems with the balance while running machines.

Almost half of the interviewees (14/31) perceived that the topic of vibration exposure was not discussed at the workplaces of the construction company. In some cases, it was perceived that the topic was discussed only when particular machines were to be used or when unusual work operations were going to take place.

Measures taken to reduce vibration exposure

Half of the interviewees perceived that the construction company had taken measures to reduce vibration exposure. The most common measures were to ensure the use of new and well-functioning machines, to use alternative work methods and to equip workers with vibration reducing gloves.

In general, the following measures had been taken at the work places: use of vibration reducing gloves; old machines changed to new ones; alternative work methods if unusual work operations; good quality of machines and appliances; work rotation when long work operations; and remote-controlled machines.

Possibilities for improvement

The site supervisors and construction workers saw several possibilities for improvements within the company regarding the occupational safety and health work and specifically concerning vibration exposure.

- Site supervisors as well as machine suppliers should ensure the use of new equipment with good quality
- Exposure for vibrations should be highlighted in the project risk inventory

- Develop simple and user-friendly methods for estimating vibration exposure
- At a new construction site as well as when new staff is added you should review the equipment and how it should be used
- Clear instructions should accompany the equipment from the supplier
- Machines should be marked with action values and limit values for vibration exposure (expressed in minutes)
- Increased education concerning injuries from vibration exposure
- Suppliers and salesmen of equipment could demonstrate new potential machines directly at the construction site
- Improve the design of machines and equipment
- The employer should inform about the risks and encourage discussions at the workplaces
- Maintain work rotation and do follow-ups
- Alternative low vibrating equipment should be considered more often.

DISCUSSION

This pilot study gave insight in how the risks for vibration injuries was perceived by site supervisors and construction workers. The conclusions drawn by the Work Environment Authority in their inspections from 2011 is also valid for the studied construction company where the management of vibration exposures can be considerably improved. Regular estimations of daily vibration exposures were not performed at the work places, and recommended tools from the Work Environment Authority for these estimations were not known by site supervisors.

Interviewed construction workers could be divided into three groups concerning existing physical complaints: without complaints; at risk; with vibration injuries. The group 'at risk' (11/21) had the highest exposure of daily vibrations (up to 17 hours per week). This group also took deliberate pauses to the least extent. A warning sign in this group is the group members risk perception or lack of risk perception. Several workers showed clear examples of vibration injuries, but they were not perceived as actual problems where to expect solutions or improvements. The injuries were perceived as normal consequences for all who work in construction and in contact with vibrating tools.

The reasons why the vibration exposure regulations have not been incorporated into the construction company and industry routines may be due to they not being communicated in a comprehensive way by the Authority or have not been prioritized by the receiver. Another important factor to why the construction industry have difficulty to apply the regulations are the psychosocial work environment as well as the prevailing safety culture among construction workers and on other organisational levels in a construction company.

Driving forces to improved proactive health and safety work

The driving forces among authorities, European as well as Swedish, to reduce the number of occupational injuries such as vibration injuries led to the introduction of the new regulations in 2005. This measure has then been followed-up by the Authority's inspections which showed that the construction industry was not applying the regulations. The motivation to develop a proactive health and safety work seems to have got stuck on its way through the construction companies' organisations.

In the current case, the interviews indicated that the motivation to strengthen the proactive work concerning vibration injuries was low at management level within the company. The managements driving forces for highlighting vibration injuries were weak. The company have had no 'campaigns' for increased information or drive at improved risk management of vibration injuries. The results show that the problem have been carried over to initiatives on production level instead of finding solutions and handling the problem on higher decision-making levels in the organisation. In order to increase the driving forces on this higher-levels extensive commitment to reduce vibration exposures is needed in the major construction company if not in the entire construction industry. In the case of falls from height and work at height which is more considered and respected today by construction workers and sweepers you can suspect that the Authorities actions and fines have played a crucial role for increasing the driving forces within small or large construction companies.

The work force in the studied construction company was not motivated enough to change their behaviour pattern: vibrations were not seen as a threat. Compared to the other physical risks that the construction work is associated with the risk for vibration injuries is less known, not as serious or immediate. There are many work operations where the risk of injury is more direct, visible and more common. For example, falls from height, handling knives and saws, and manual handling of loads. An injury that are more direct gets more attention compared to injuries that more discreetly sneak up on you over time which is often the case with vibration injuries.

Safety culture in construction

The construction industry has for a long time been demographically homogeneous and static: above all the work force is male-dominated with low diversity. Also, the members of the work force are often isolated from other activities in a construction project contributing to the internal strength of the specific workgroups. The strong group membership and the distinct hierarchies on, above all, work force level make it difficult to change the safety culture within a construction company.

A construction project involves many different competencies that not necessarily can cover for each other. Every co-worker is a specialist in his/her field: a machine operator can not do the job of a construction worker and vice versa. Therefore, it can be difficult to introduce changes at the work place if the changes only concerns one group category.

The site supervisor may not have the same understanding for or practical work knowledge as the construction workers if the supervisor has made a career from another group category. Therefore, the site supervisor may experience difficulties in changing the behaviours in a group as the supervisor in some way do not belong to the group.

The many groups of specialists at a construction site can make it difficult to give criticism as well as introducing common frameworks concerning the work environment and routines.

Furthermore, an important effect on the safety culture in construction is the attitude towards physical injuries - that some injuries naturally comes with the work. It is strenuous with physical work and many of your colleagues have suffered physical complaints during the working life. There seems to exist a general acceptance of injuries- it is more normal to suffer from a physical complaint than not.

There is a need for a change in construction workers attitudes that long-term injuries do not need as much as attention as short-term injuries. The studied construction company had a zero vision concerning injuries at their workplaces. The vision concerned both short-term and long-term injuries. This means that the long-term injuries need to be prevented even if they on the surface have a seemingly less effect on the daily work.

Improving the management of vibration exposure

A construction company and other actors in the industry could with rather simple means and measures improve the management of work with vibration exposure. Some of the interviewees many reflections and suggestions for improvements are given in the results section. Measures that have the potential to improve the management of vibration exposure is to design user-friendly methods and systems for estimating daily vibration exposure and to raise awareness among workers at the work sites by giving clearer risk information about the machines and equipment used in daily work. In order to increase knowledge and awareness among employees about vibration injuries and change attitudes that negatively affect health and safety at work an educational program with focus on vibration exposure is suggested. All organisational levels of a construction company are to take part. The knowledge and attitudes to risk and safety on top management levels in a company (and in any industry) are extremely important for creating positive safety attitudes and good safety behaviours among the workforce of the company.

In order to reduce occupational exposure to hand-transmitted vibration several types of vibration reducing gloves have been developed. A few studies have reported that some of these gloves could be helpful (e.g. Mahbub et al. 2007), but other studies show their effectiveness remains unclear, especially for finger protection (Welcome et al. 2014).Vibration reducing gloves may be uncomfortable to wear and cause hand fatigue (Welcome et al. 2014) and can reduce finger dexterity and increase handgrip effort (Wimer et al. 2010). It has been shown that the vibration isolation performance of gloves is tool- and operation-specific. However, the effectiveness of gloves when used with specific vibratory tools has not been well studied (Dong et al. 2003). This is often due to the challenging task of objectively measuring hand-arm vibrations at work: exposure depends on the circumstances in which a task is executed; the tools used; the material being processed; and individual worker's characteristics (Coenen et al. 2014).

The research method applied in the pilot study

This pilot study was based on information gained through interviews with 10 supervisors and 21 construction workers at nine construction sites in southern Sweden. The research material was too small in order to draw any far-reaching conclusions. The interviewees were asked to estimate how long (hours per week) they worked with tools and machines that vibrate. Their answers may not reveal actual working hours but instead the duration of time needed to complete a work task where work with vibrating equipment is included. It was beyond the scope of the study to obtain measured exposures to vibration and it was therefore impossible to determine whether or not the reported vibration exposures were hazardous. However, the part of the interview focusing on organisational aspects of vibration exposure, such as routines for risk assessments, risk awareness and knowledge about health consequences, and measures taken to reduce vibration exposure are believed to have yielded reliable results.

CONCLUSIONS

The following conclusion from the pilot study can be drawn:

- The Swedish Work Environment Authority's regulation on vibration exposure is not satisfactorily acted on in the construction industry.
- Estimations of daily vibration exposure is not performed at the work sites.
- Driving forces for improving the proactive health and safety work and specifically vibration exposure management is weak on all organisational levels.
- Important factors affecting the implementation of vibration exposure regulations are the psychosocial work environment at construction sites as well as company safety culture.
- A large proportion of the interviewed construction workers is judged to be at risk for developing vibration injuries if the exposure is not decreased.
- Management, supervisory, and production levels need increased knowledge about vibration exposure and vibration injuries.
- Methods and tools for easy estimation of vibration exposure need to be developed.

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