Exposure and risk quantification for improved relationship assessment in occupational investigations

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Data gathered in occupational workplace investigations can be used as a source to improve the statistics. The aim of this paper is to start a discussion on how this can be done. Some suggestions for this are given: e.g. that there should be an increased use of quantitative data in occupational investigations. The number of variables used in exposure quantification should be limited and agreed upon. The variation in terminology should be reduced by improving the definitions of the terms used and also by developing a methods standard. In this way the relationships between exposure and effect could be formulated in quantitative terms. There are many influencing factors which affect the possibility to make comparisons over time, but increased use of precise concepts and standardized methods can result in much better statistics.

Keywords: Exposure, occupational risk assessment, dose-response, standardisation

1. Introduction

From numerous studies of occupational work load and disorders in professional groups there is general agreement that there is a relationship. For a Swedish compilation and evaluation, see Report 210 by SBU, the Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU 2012). Too high work load results in bodily disorder after enough strong exposure. Despite the number of studies the relationship between cause and effect is not very well determined. There are several reasons for this.

In many occupational investigations the aim is to identify the risk for harmful conditions, and then through different measures reduce the risk to an acceptable level, or preferably to zero as the aim is that nobody should get hurt in the job. However, it is not the risk that is assessed, even if it is said so, but rather the exposure, usually determined as load level and rarely as load dose

Ideally then the exposure assessed should be related to injury outcome through dose-response relationships and a risk measure obtained. This means that dose-response relationships play a very important role. Unfortunately, established dose-

response relationships are seldom available. A reason for this is that the relationships are quite tedious to determine, they must be based on relatively large materials and they require precise definitions and assessments of both load and response. Instead agreed classification of exposure is used as a risk indicator for action (e.g. Hansson et al. 2016).

In the practical investigations made at company level the origin is that a person has started to complain about ache or pain from a body part and reports this to the occupational health service in order to get some help. The OHS is then required to do an investigation. Such an investigation has two parts: the first concerns characterisation of the symptoms the person has, and the other is an exploration of exposure factors that can have caused the symptoms, both should be in quantitative terms. A third part that should also be considered in the investigation is to determine possibilities to improve the work situation. This means that both response related and dose related factors are gathered even if they are not carefully recorded. With little extra effort, these findings can be used to continuously improve the statistics. The aim of the present paper is to start a discussion of how actions for such improvements can be done as part of the OHS routine and result in much better statistics.

2. Exposure assessment

The aim of exposure assessment is to grade the degree of loading a job or work moment entails. The assessment involves two entities, viz. (1) grading of the load level and (2) estimating the time duration of the loading. Many of the methods for work load assessment are handling grading of load level quite well while time duration assessment is quite difficult since peoples work is varying a lot concerning both type and duration.

There are a large number of more or less reliable methods available to identify and assess exposure, many of which are qualitative and based on judgement of observations. The methods are commonly categorized under three main headings: subjective judgments, systematic observational methods, and direct (or technical) measurement methods (e.g. Kuorinka et al., 1995).

One of the first methods for assessing awkward or strenuous postures by observation is the OWAS method presented by Kahru et al. in 1977. The method was very welcomed as it led to an ordered structure of observations that could be used at the workplace. It rated observed postures of the whole body and classified them in four classes according to the urgency for action. This method was later followed by the also very often applied Rula method (McAtamney and Corlett 1993) providing a quick assessment of the postures of the neck, trunk and upper limb. Both these methods gave a structure to the observations made by an experienced investigator directly at the workplace. They also presented a way of grading the severeness of the assessed exposure based on reports available at the time and the authors' experiences from own work place investigations.

These two methods and similar methods that have been developed over the years (see e.g. Takala et al., 2010) became very popular among investigators as they were considered very easy to carry out and did not require any instrumentation. Also the recommended structure for classification of the observations simplified the

evaluation of the work load and conclusions on what should be done. Despite appearing simple to carry out, the observations require a certain experience and skill by the investigator. That this is a problem in the practical use of observational methods is shown by the rather low accuracy of the methods (e.g. Palm, 2016). Another problem with the methods is that they are based on direct observations and after a session only the observer's notes remain meaning that the work studied cannot be rechecked. By video recording of the observed work this drawback can be remedied and is often done, but then some of the simplicity of the method is lost.

3. A comment on scaling

The aim of work load assessment is to make observations at a work place and evaluate the load assessed to determine whether it is harmful or not. This is basically a dichotomous decision. But since there is always a degree of uncertainty about borderline cases, the need for a borderline class arose, a need that lead to the establishment of the *traffic light scale* with its three levels. Green means that the job or work moment is without risk for harm or injury and therefore acceptable. Red means that the job involves an unacceptable risk for harm or injury and that the job must be improved as soon as possible. Yellow means basically that no clear decision can be made and that the work situation needs to be investigated further. However, it did not last long until the traffic light method became established as a scale of three levels often even numerically quantified as 1 for green, 2 for yellow and 3 for red. This should be looked upon as an ordinal type scale, but the numerical values have invited treatment (incorrectly) as an interval scale. Since the borderline uncertainties still are inherent, this has led to the introduction of half-steps between the colours leading to a scale with five steps. Despite the number of steps or grades this does not result in very precise characterisation of exposure since it depends on the structure and accuracy of the underlying assessments.

4. Transducer based measurements

To improve the workload assessment quantitative methods should be used. For the load level, new possibilities for more precise assessments have become available in recent years. Through development of transducer technology (for movements, acceleration, forces and moments), signal conditioning and recording equipment as well as computer based analysis software, more occupational investigations can be based on direct measurements with reliable and precise assessment of exposure. Good examples of what can be achieved have been given by Hanson et al. (2016). However, despite these achievements in measurement techniques, the measurements may still be too difficult to carry out for use in everyday occupational health work.

5. Computer manikin simulations

Another very promising possibility is to use the simulations of work that are done more or less routinely in early phases of production preparations in technically advanced companies using computer manikin software. When the structure of the computer manikins involved is detailed enough, the modelled movements of the body

parts can be recorded and used for kinematic assessment of postures and movements, statically as well as dynamically as both snapshots and the time variations of the exposure variable can be recorded (e.g. Keyvani et al., 2013), and, with suitable biomechanical models, even kinetic assessments can be made so that postures, movements, gravitational loads and acceleration forces can be determined.

Thus, the biomechanical modelling introduced in manikin software permits also kinetic assessments, i.e. assessment of the forces acting on, in and between the body parts in addition to the kinematic assessments of postures and movements. The IMMA manikin software developed jointly by Chalmers and Fraunhofer Institute is an example intended for industrial applications (IMMA 2014). This means that exerted forces, gravitational loads and acceleration forces can be determined and used as exposure variables. Even if the biomechanical models used in the software are advanced and based on sophisticated considerations, the use of the software can be quite straightforward and easy to manage. Thus a number of questions concerning internal forces and moments in the body during work can be answered. Unfortunately the usefulness of kinetic quantities in risk assessment is limited at the present time since connected response data are not available. This situation can be expected to be improved in the future as the results from kinetic analyses become available together with concomitant injury statistics.

6. Time and load dose

Even if quantitative methods for assessing the load magnitude are used, it is still problematic to determine the time extent of the exposure. The harmful effect of an exposure depends on both the magnitude and the time extent; the load dose being calculated as the summed or integral of the product of the magnitude and the time. Here some new questions arise, namely whether the load dose is additive in the meaning that if the load dose is doubled, does the response also double. A variant of this is whether a certain load dose is equivalent to another in which the load is halved and the time extent doubled.

The time aspects of the exposure should be recognised better when acquiring dose-response data for epidemiological considerations. This not so easy, however, as time records of the load history for individuals are hard to obtain due to the variability of the employment situation in many companies. In companies where the mobility is less it should be possible to get data on which jobs a person has had and for how long since such data are recorded. If these data are put together with work load data from computer simulations of the work, it would be possible to obtain very useful statistics on dose-response in such jobs.

7. Quantification of symptoms

On the effect side the classification of symptoms need to be improved as the symptoms are denoted verbally and not easy to quantify. Descriptive words like pain, trouble, distress and even fatigue are common. A further trouble is the wide spread of work-load assessment methods in use. Even if the different methods have much in common they do not give simply comparable results. A consequence of this is that despite all the information that is available, it is hard to systematise this information and use it to

establish precise relationships between cause and effect or to perform deeper analyses aiming at for example better understanding of injury mechanisms.

8. Need for quantitative data and a methods standard

In order to remedy the situation there should be an increased use of quantitative data in occupational investigations both concerning exposure and symptoms. Another issue is to try to reduce the variation in terminology by improving the definitions of the terms used and also to develop a methods standard. In this way the relationships between exposure and effect could be formulated in quantitative terms. On the exposure side there are several possibilities for improved quantification of exposure, level as well as duration. Also the variables to be used in exposure quantification must be agreed upon. This is not an easy task, however, as workload can be characterised by so many variables.

9. Load dose and risk

When interpreting the load dose relationship, it must be remembered that it is a statistical concept. This means that if individuals in a population are subject to a given load dose, only a certain percent of them will develop symptoms of harm or injury. What is then a safe dose level? A level which causes problems in one percent of the population, or should five percent be acceptable? To bring order in the reasoning about dose-response issues of this kind must be clarified.

Casually the word risk is used with several meanings to indicate how possible it is that an unfavourable event will lead to harm under certain circumstances. In occupational contexts risk is used to indicate the likelihood that an injury or accident will occur. The likelihood or probability that a single event (injury or accident) will occur is perhaps not so meaningful in a certain situation as the event will either occur or not. The meaning becomes clearer if the conditions are repeated under the same circumstances. Then the likelihood signifies the relative frequency of occurrence of the event. Here both likelihood and relative frequency can be expressed in percent.

The risk concept has also a different meaning, however. In risk science it is defined as the probability of an event times the consequence of the event. The risk can then be expressed as the cost a single event amounts to, or as a yearly cost for the events that takes place during a year.

Both these risk concepts are important in occupational health work and there should be a definite strive to put figures to the risks by putting together available data. This can very well be done locally in a company, and by having such compilations, it is possible to follow the development of harmful conditions over time and also the effect of measures undertaken. Of course there are many influencing factors which affects the possibility to make comparisons over time, but by increased use of precise concepts and standardized methods these can be overcome resulting in much better statistics.

10. Conclusions

There should be an increased use of quantitative data in occupational investigations. The variables to be used in exposure quantification should be agreed upon. This is not

an easy task, as workload can be characterised by so many variables. Another issue is to try to reduce the variation in terminology by improving the definitions of the terms used and also develop a methods standard. In this way the relationships between exposure and effect could be formulated in quantitative terms.

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